THIS NUMBER COMPLETES VOLUME 11

Vol. 11 DECEMBER, 1940 No. 4

CHILD DEVELOPMENT

Editorial Board

CARROLL E. PALMER,
Chairman
E. V. McCOLLUM
FREDERICK F. TISDALL
RICHARD E. SCAMMON
MANDEL SHERMAN
HAROLD E. JONES
F. STUART CHAPIN

PUBLISHED QUARTERLY BY THE SOCIETY FOR RESEARCH IN CHILD DEVELOPMENT
NATIONAL RESEARCH COUNCIL
2101 CONSTITUTION AVENUE
WASHINGTON, D. C.

Made in United States of America

CHILD DEVELOPMENT

Vol. 11

DECEMBER, 1940

No. 4

Editorial Board

E. V. McCOLLUM
Professor of Biochemistry, School of Hygiene and Public Health, The Johns Hopkins University.

RICHARD E. SCAMMON
Distinguished Service Professor Graduate School University of Minnesota

HAROLD E. JONES
Director, Institute of Child Welfare, and Professor of Psychology, University of California.

FREDERICK F. TISDALL
Director, Research Laboratories, Department of Pediatrics, University of Toronto, and Attending Physician, Hospital for Sick Children, Toronto.

MANDEL SHERMAN
The University of Chicago, Chicago, Illinois.

F. STUART CHAPIN
Professor and Chairman of Sociology and Director Graduate Social Work, University of Minnesota.

CARROLL E. PALMER, *Chairman*
Past Assistant Surgeon, U. S. Public Health Service.

PUBLISHED QUARTERLY BY THE SOCIETY FOR RESEARCH IN CHILD DEVELOPMENT
NATIONAL RESEARCH COUNCIL
2101 CONSTITUTION AVENUE
WASHINGTON, D. C.
Made in United States of America

AN ANALYSIS FOR MULTIPLE FACTORS OF PHYSICAL GROWTH AT DIFFERENT AGE LEVELS[1]

C. H. McCLOY[2]

Many students of human growth have observed not only that there are rhythms of growth, but also that one type of growth seems to predominate at one time and another type of growth at another time. Thus, at the onset of adolescence, a spurt of growth of the long bones is often seen, which is followed later by an acceleration of growth of the cross-sectional measurements. Meredith (6) and Boynton (1) have both shown that the growth rate of subcutaneous fat tends to be reduced when linear and cross-sectional growth rates are accelerated, while the growth rate of fat accelerates when linear and cross-sectional growth rates decline.

Such observations suggest a number of questions like the following:

1. How many distinct types of growth are exhibited by the human body?
2. Can these types of growth be isolated and identified?
3. Is growth in certain dimensions a compound? If so, of which growth factors is it compounded, and in what proportions?
4. Are there marked age differences in these different types of growth as they affect each measurement?
5. In the light of the facts, what can we learn that would help us to solve the problem of classifying body types for different purposes?

If it is possible to resolve growth into such relatively clear-cut factors or types of growth, the knowledge of these factors should aid measurably in facilitating the solution of many problems of physical anthropology as they apply to the growth of the child.

In the light of some recent mathematical publications it would seem that such methods for separating and isolating growth factors are available. The stimulus for the invention of such methods came from the two-factor theory of Spearman. Spearman (7), in 1927, published a method of separating a number of variables into one general or common factor, plus a number of specific factors, the number of which specific factors was the same as the number of variables. The application of this method was restricted to such variables as possessed only one general or common factor. Many of the mental tests to which this method was applied, together with a large number of motor tests and growth variables, were seen to possess a large number of such common factors. In 1928, T. L. Kelley (4) proposed a method which extended the Spearman method to more than one general factor, but this method had other limitations which discouraged its use.

More recently two methods have been devised, each of which seems to have no limitations as to the number of factors common to all the variables or to any group of them. Either seems to be satisfactory. The first of these two methods, that presented by L. L. Thurstone (8), pre-

[1]*Much of the expense of the statistical computations connected with this study was financed by a grant from the Carnegie Foundation for the Advancement of Teaching.*

[2]*From State University of Iowa.*

sents considerably less difficulty in computation than does the second, that proposed by Hotelling (3). With known communalities inserted in the diagonals of the correlation matrix before computation,[3] the two methods give identical results. Both methods require rotation before the factor loadings become meaningful. A recent study has shown that with unknown communalities, the Thurstone method gives the more accurate results (5).

When this method of factor analysis is applied to a number of variables, such as the anthropometric measurements used in this study, the end result of the computations after rotation consists in a number of "factor loadings" which are, in effect, zero-order correlations with each of the isolated factors. These computations may be carried out to a relatively large number of factors, in which case it is highly probable that the first few will be factors common to all or to a large part of the variables, while, as the number of these isolated factors increases, their correlations with the individual variables give indications that the succeeding factors are relatively specific to a very small number of variables. In the present study, three important factors common to a relatively large number of variables have been isolated or tentatively identified, and a fourth factor is present in most of the age groups. The factor seems to be a minor group factor, and the loadings are very small in size.

If all of the factors of growth, common and specific, were measured and isolated by this method, and if there were no errors of measurement (in other words, if there were perfect reliability and objectivity of measurement), the sum of the squares of all of the factor loadings of a given variable would be unity. It will be seen that this is not the case in this study. The sum of the squares of some of these factor loadings approaches unity. Others are only partially accounted for. The difference is compounded of two elements. The first is any factor or factors specific to that particular measurement.[4] The second consists of "errors," or unreliabilities of the measurement. For example, the reliability and the objectivity of weight are almost perfect. There is considerable variation, however, in the measurement of shoulder width, which is so much affected by the way in which the shoulders are held by the individual, and of breathing capacity, which is almost as much of a mental test for many very young individuals as it is a test of the amount of air that can be exhaled from the lungs.

MEASUREMENTS TAKEN

All, or a large proportion, of the following measurements were obtained upon the several age groups in both sexes:

1. WEIGHT
2. TOTAL HEIGHT
3. SITTING HEIGHT
4. BI-ACROMIAL WIDTH OF THE SHOULDERS
5. BI-CRISTAL WIDTH OF THE HIPS

[3] *The communality for any variable is the sum of the squares of all of the factor loadings for the variable.*

[4] *It should be remembered that a factor may be specific to one variable in one battery, and common to several or all variables in a different battery.*

6. WIDTH OF CHEST
7. DEPTH OF CHEST
8. GIRTH OF CHEST (All chest measurements were taken at the level of the xiphoid.)
9. BREATHING CAPACITY OF THE LUNGS
10. WIDTH OF LEFT ELBOW AT THE EPICONDYLES
11. WIDTH OF LEFT KNEE AT THE EPICONDYLES
12. GIRTH OF LEFT UPPER ARM, EXTENDED DOWNWARD
13. GIRTH OF LEFT FOREARM
14. GIRTH OF LEFT THIGH
15. GIRTH OF LEFT CALF
16. SKIN AND SUBCUTANEOUS FAT THICKNESS ON THE LEFT FRONT OF CHEST (at the xiphoid level, midway between the sagittal planes running through the left axilla and the sternum, respectively)
17. SKIN AND SUBCUTANEOUS FAT THICKNESS OVER THE BACK (at the xiphoid level, over the most prominent swelling of the left erector spinae)
18. SKIN AND SUBCUTANEOUS FAT THICKNESS ON THE FRONT OF THE LEFT ARM (over the biceps, midway between the acromion and the elbow)
19. SKIN AND SUBCUTANEOUS FAT THICKNESS OVER THE LEFT TRICEPS (midway between the acromion and the elbow)

These measurements were all intercorrelated and then analyzed by Thurstone's center of gravity method of factor analysis, and rotated by the two-at-a-time method of successive rotations.

PRELIMINARY STUDY

Preliminary studies were made upon two groups. These two groups were composed of Freshman men and women at the State University of Iowa (see College Ages, Tables 1 - 20).[5] Ages ranged from eighteen years to twenty years. In this study five factors were computed in order to determine how many significant factors might be isolated. Four of these were felt to be of considerable significance. The fifth was small and gave little promise of being significant so far as the isolation of a common or group factor was concerned.

THE MAIN STUDY

After this preliminary study was completed, similar data were analyzed for the following additional age groups:

Boys, ages 9 days, and 4, 6, 8, 10, 12, 14, and 16 years
Girls, ages 9 days, and 4, 6, 8, 10, 12, 13, 15, 16, and 17 years.

In each of these groups the computations were carried out to five factors, and if the fifth factor seemed at all promising, to a sixth factor. The fifth and sixth factor residuals were, of course, computed in such cases. In the final analysis, however, none of the factors beyond

[5] *It should be remembered that many of the differences in the factor loadings from age to age are explainable in terms of sampling. Factor loadings are functions of intercorrelations. It is well known that in successive samples of the same population the intercorrelations will vary to a considerable extent. This should be kept in mind in studying these factor loadings.*

the fourth seemed significant.[6] In each age group the same three factors appeared, and in almost all the groups the fourth factor was evident. In the analysis for these factors the measurements of fat and subcutaneous tissue seemed, on the whole, to be the least complicated. These four measurements stood out in one factor, and were almost always well grouped. Hence, in rotating we ran one plane through them, and have called this factor that of "growth in fat." It is, in each case, the first factor.

The second factor is that which is weighted highest in the linear measurements, such as in height and sitting height. In other studies on adults (see later in this paper) this factor is also high in lengths of upper arm, forearm, lower leg, foot, etc. It is practically orthogonal to the fat factor, and not compounded significantly with it. Almost all variables, except the fat measurements, have some significant loadings with this factor. In view of the high loadings in the variables that represent linear growth (lengths and height), we were tempted to call it a "linear growth factor." In view, however, of the fact that it is present in almost all variables except fat, we shall tentatively call it a "general growth factor." This latter assumption seems to be substantiated by a subsequent study discussed below.

The third factor is one that is most heavily loaded in the girths, widths, and depths. In general, it has its heaviest loadings in the limb girths: arm, forearm, thigh, and calf, and next in the girth, width, and depth of the chest. All of these, except the chest width, have much muscular tissue inclosed within the tape or calipers; but in view of the fact that, as measured, the chest width does not include any significant amount of muscular tissue in the measurement, we are not justified in calling it a "muscle factor." We shall call it, for convenience, the factor of "growth in cross section" or the "cross-sectional factor." For the present this term may be considered as descriptive and not explanatory. This factor is seldom seen in pure form, for the variables that are weighted with this factor are also weighted with the fat factor since fat also lies under the tape or calipers.

The fourth factor is not entirely consistent. It might be thought to consist purely of deviations from a residual plane if the variables found loaded most heavily with it in the various age groups were not the same ones. It is usually most heavily loaded in the variables of chest girth, depth, and width, and sometimes in the width of the shoulders. It is, however, the least consistent factor, and varies the most. We shall make no attempt to name it, but shall simply call it "Factor IV."

It may be interesting to note that Growth Factor II (general growth) is of such a nature that if it were functioning strongly and the other three factors were not, the individual's build would be linear or asthenic. Growth Factor III, (cross-sectional growth) functioning heavily, would produce a lateral or pyknic build. Growth Factor IV would add a tendency toward Kretchmer's athletic type of build - large chest and wide shoulders.

In this study the data are presented in two ways. First, the rotated factor loadings are given as obtained. In this set of factor loadings there are numerous divergencies from age to age in the same sex. To attempt to iron out adventitious variations, these loadings were smoothed

[6] *The judgment of "significance" was based on the size of the residuals and upon whether or not such a factor seemed identifiable.*

twice by the method of running averages. Both were plotted for study (one variable at a time being plotted for all four factors over the whole age range). In Tables 1-20, both of these loadings are given. The original loadings are given in roman type, and the smoothed loadings are underlined at the lower right.

With minor differences, the variables fall into six groups:

1. WEIGHT AND BREATHING CAPACITY
2. HEIGHT AND SITTING HEIGHT
3. WIDTHS OF SHOULDERS, HIPS, ELBOWS, AND KNEES
4. DEPTH, WIDTH, AND GIRTH OF THE CHEST
5. LIMB GIRTHS
6. FAT MEASUREMENTS

Of these groups, the chest and the limb girth groups have much in common.

The trends within these groups are discussed below. The approximate "average factor loadings" are taken by inspection from the smoothed loadings. The actual loadings, both raw and smoothed, may be obtained from Tables 1-20. Charts 1-12, illustrating a number of the factors, both in their original form and smoothed, are presented as an aid to understanding the nature of the results.

1. Weight and Breathing Capacity. In our data we do not have breathing capacity records for children under eight years of age. The factor loadings for weight and breathing capacity resemble each other in that the general growth factor is the most heavily loaded in both. For weight, this averages a factor loading from .65 to .70 in both sexes, but falls off somewhat after puberty. In breathing capacity this factor has a factor loading that averages about .65 to .70 in boys and between .55 and .65 in girls. The loadings fall off after puberty in both sexes.

As would be expected, the fat factor has moderate factor loadings with weight - from .35 to .40 in boys, and from .45 to .60 in girls. In breathing capacity it is approximately .00 in both sexes.

The cross-sectional factor is moderately high in both measurements - averaging for weight from .45 to .60 in both sexes, and from .20 to .25 in breathing capacity.

Factor IV is negligible both in weight and breathing capacity.

2. Height and Sitting Height. These measurements are very heavily weighted with the general growth factor, and with very little else. The factor loadings for this factor for height run from .90 to .98 for boys, except for the infants in both sexes. Those for sitting height vary around an average of .85 for both sexes. For some reason the fat factor is fairly high in height (beyond logical expectancy) at the nine-days old level - up to .60 in boys and .30 in girls. It does not appear significantly in this measurement after that.

3. Measurements of Widths of Shoulders, Hips, Elbows, and Knees. These measurements have much in common. The fat factor is very lightly weighted in all though it is more in evidence in the girls than in the boys. In the boys it runs from an average of .15 (shoulders and elbows) to an average of .25 (hips and knees). In the girls it averages about .25 and .35 for these two groups, respectively.

The general growth factor, the one most concerned in linear growth, is the one that is most prominent in all forms of these measurements.

The reason for this is evident in the case of the shoulder width. If one remembers that hip width varies essentially as the product of twice the length of the innominate bones and the sine of the angle of those bones with the sagittal plane, it will be seen that hip width is really a "linear" measurement.

The logic of the relationship between the widths of the elbow and knee to this type of growth is not clear, but the fact remains that in almost all age groups this type of growth is predominant in these measurements.

The cross-sectional growth factor loadings for these measurements average about .30 with various fluctuations. Type IV is present only in shoulder width, except for hip width in girls, and it is low in all of these measurements, seldom averaging above .20 to .25.

There is a very slight tendency for the general growth factor and the cross-sectional growth factor to alternate: that is, when the one goes up, the other goes down. It is not clearly evident throughout, however, and may be merely a function of the sampling.

4. Measurements of the Chest. These measurements are significantly weighted with all factors. The fat factor varies from an average of .20 to one of .50, with a general average of nearly .40. The cross-sectional factor has weightings that average from .40 to .60, with a general average of about .50. The general growth factor varies from an average of about .30 to one of .55, but tends to fall off by the time the individual is eleven or twelve years of age. Factor IV here shows fairly significant loadings, running from an average of .22 to one of .60. The general average is low before the age of ten or twelve - about .25 - but increases to a general average of nearly .50 at the college ages. It is in this group of measurements that this factor is most prominent.

Factor IV and the cross-sectional factor tend to vary inversely: that is, when the cross-sectional factor increases, the fourth factor tends to diminish; and vice versa.

5. Limb Girths. In these measurements each of the first three factors is fairly heavily weighted. Since there is subcutaneous fat under the tape, as would be expected, the fat factor is rather prominent, averaging, in the different measurements, from .40 to .65, with a general average of about .55. This tends to fall off somewhat in the case of individuals over ten and twelve years of age.

What we have called the cross-sectional factor has average weightings from .50 to .65, with a general average of somewhat over .55. This tends to increase after the individual is ten to twelve years of age.

The general growth factor also is well represented, especially in the ages before ten. It has weightings averaging from .30 to .50, with a general average of about .40. It tends to fall off in girls over twelve years of age and in boys over fourteen years of age.

There are no significant loadings with the fourth factor in any of these variables.

There is a slight tendency, especially with the boys, for the general growth and the cross-sectional factors to vary inversely: that is, as the general growth factor increases, the cross-sectional factor diminishes, and vice versa. This tendency is not quite as marked with the girls.

These last two groups of measurements - the chest measurements and

the limb girths - have much in common, especially the heavy loadings with cross-sectional and general growth factors. The limb girths, however, are not significantly weighted in the fourth factor, and tend to show a heavier weighting in the fat factors, possibly because fat in these smaller measurements is a larger part of the whole cross-section.

6. Measurements of Fat and Subcutaneous Tissue. In these measurements there is only one factor of importance - what we have called the "fat factor." The factor loadings for this fat factor average from .70 to .80 for all ages and both sexes. The trunk fat gives consistent loadings of about .80 for both sexes as do the measurements of fat on the arms for the boys. In the girls, this drops on the arms to about .70. The other three factors fluctuate around loadings of zero, and are not significant. These measurements seem to be relatively pure in this factor.

Further light is thrown upon the nature of Factor II (the general growth factor) by the analysis of data obtained from the Bureau of Home Economics, the Department of Agriculture of the United States Government. This Department has conducted an anthropometric study of children of both sexes, four to seventeen years of age, inclusive, for the purposes of standardizing clothing measurements. The author was associated with this study in its preparation and was the director of the study for the state of Iowa. He has knowledge that the measurements were accurately taken.

In this study no fat measurements were taken, and all ages were combined for the intercorrelations. These correlation matrices were factored in this laboratory. Only two factors of sure significance could be isolated. When rotated, these seem to be Factor II (the general growth factor) and Factor III (the cross-section factor). It is significant that in this study over such a large age range, the general growth factor was present in very large measure in all of the measurements, cross-sectional or linear. The results are shown in Table 21, where the factors of the boys are shown in roman type at the upper left, and those of the girls are underlined at the lower right.

After the analyses presented above had been studied, a number of questions presented themselves. Hence two other anthropometric studies of adult male and female college students were projected. Thirty-two measurements were analyzed in the first study on males, and thirty-seven measurements in the study on females. The age range of males was from seventeen to twenty-two years, and of the females from seventeen to twenty-one years. The measurements on the males were taken by Dr. W. W. Massey, and those on the females by Dr. Ruth I. Bass, who at that time were cooperating with the writer in anthropometric studies for other purposes.

The measurements both for males and females were factored to seven factors. In the males the residuals beyond the fourth factor become very small, and in the females those beyond the fifth factor become very small. Plots of each of the subsequent factors against each of the others gave no indications of possessing significance.

The measurements studied were as follows:

1. WEIGHT
2. HEIGHT
3. SITTING HEIGHT (males only)

4. SITTING HEIGHT TO CERVICALE
5. PROJECTED LENGTH, CERVICALE TO LUMBALE
6. LENGTH STERNUM
7. LENGTH UPPER ARM, ACROMION TO RADIALE
8. LENGTH FOREARM, RADIALE TO STYLION
9. LENGTH HAND
10. LENGTH LOWER LEG, TIBIALE TO SPHYRION
11. LENGTH FOOT
12. LENGTH CLAVICLE
13. LENGTH FROM STERNAL END OF CLAVICLE TO ACROMION
14. LENGTH 10th RIB, FROM SPINE OF 9th RIB TO JUNCTION WITH COSTAL CARTILAGE (measured around the thorax with a tape)
15. WIDTH SHOULDERS
16. WIDTH HIPS (at iliocristale)
17. WIDTH HIPS (at iliospinale anterior)
18. WIDTH TOP OF ILIUM FROM ILIOSPINALE ANTERIOR TO ILIOSPINALE POSTERIOR
19. WIDTH ELBOW
20. WIDTH KNEE
21. DEPTH CHEST AT XIPHOID
22. WIDTH CHEST AT XIPHOID
23. GIRTH CHEST AT XIPHOID
24. GIRTH NECK
25. GIRTH UPPER ARM
26. GIRTH FOREARM
27. GIRTH THIGH
28. GIRTH CALF
29. BREATHING CAPACITY OF THE LUNGS
30. FAT, CHEST FRONT
31. FAT, CHEST BACK
32. FAT, ABDOMINAL (midpoint between nipple and umbilicus)
33. FAT, SUPRAILIAC (5 cm. above iliocristale in axillary line)
34. MID-DISTANCE FROM PORION TO OPISTHOCRANION (females only)
35. MID-DISTANCE FROM PORION TO NASION (females only)
36. MID-DISTANCE FROM PORION TO SUBNASALE (females only)
37. COSTAL ANGLE, MID-BREATH, RECLINING (females only)
38. COSTAL ANGLE AT FULL INSPIRATION, RECLINING (females only)

The results of the rotated factor loadings are tabulated in Table 22, where the factor loadings for males are tabulated at the upper left in roman type, and those of the females are underlined at the lower right. Where factor loadings are omitted, that measurement was not taken on that sex.[7]

In these studies the same four factors - fat, general growth, cross-sectional growth, and the "Factor IV" (most prominent in the chest measurements and shoulder width) - were found in both samples, details of which may be studied from the tables. As might be expected, the fat factor was more prominent in the females.

In these studies a number of measurements of lengths were included, and these are almost all heavily loaded with the general growth factor.

[7] The anthropometric measurements were originally planned for other purposes; hence the measurements were not identical in the two studies.

In this factor the measurements of the females are the more consistent.

There are some important differences in the cross-sectional factor loadings in the two sexes, for which we have no explanations.

Factor IV is more heavily weighted in the lengths of the clavicle and width of shoulders in the males, but more heavily weighted in the chest width and girth in the females, and this factor is also found to be heavily represented in the measurements of the costal angle in the females.

The females have another, or fifth, factor which has significant loadings only in the three head measurements. This is probably the type of growth that Scammon (2) calls "neural growth," which characterizes the growth of the brain, head, and other appendages of the skull, such as the size of the eyeballs. These measurements were not taken on the males.

DISCUSSION OF RESULTS

The results of these studies would seem to indicate that there is fairly consistent evidence that there are at least three quite different types of general bodily growth from birth to maturity, in addition to the nervous type (V) found in the adult women. The fourth factor (IV) is not as clear-cut, and will need much more confirmatory evidence before it can be clearly identified. The fact that these types do represent different kinds of growth is seen in those individuals in whom one type has been predominant. The "fat type" (I) is all too common, and this kind of growth can be superimposed on any kind of body build if glandular conditions become favorable. It may possibly be the result of a low thyroid or posterior pituitary output. The relatively pure "general growth type" (II) is seen in the very tall, long-limbed, excessively slender persons, and may possibly be due to an excessive output of thyroxin or certain hormones of the anterior pituitary. The relatively pure "cross-section type" (III) is seen in those persons having a short, very-stocky, broad-headed, short-limbed, lateral, or pyknic build. If "type IV" is a pure type of growth, it is probably seen best in those individuals who are very large chested and wide shouldered in comparison with their thickness of skeleton in general, and hips in particular. It would seem that size of the costal angle will vary with this factor. We do not wish to hazard an opinion as to what glandular or hereditary (gene) conditions might produce these latter two types of growth. Excessive growth in the "neural type" (V) is seen in those individuals with very large heads and eyes that are out of proportion to the size of the rest of the body.

It would seem that Factor III (the cross-sectional type) supplements Factor II as it were. Factor II seems to be present in a large number of measurements, in a few of which, such as height and the lengths of some of the long bones, it is found in an almost pure form; but in other measurements, as in the chest measurements, the second factor is present as well as the cross-sectional factor. This is found to be the case in the younger ages more than in the adults.

Scammon (2) has presented four types of growth: (1) general growth, (2) neural growth, (3) lymphoid growth, and (4) genital growth. In this

study no measurements have been studied that touch upon the latter two. In the last study presented (adult women), the neural type of growth has been confirmed, and in all of the studies, the "general growth" has been shown to be divisible into four subdivisions: (1) fat, (2) general, (3) cross-sectional, and (4) what we have chosen to label simply "type IV" because of the difficulties in the way of better identification. This would seem to leave us with at least seven types of growth instead of four.

It should be easily possible to study these types further, especially the first three types presented in this study, and the neural growth - and to measure them in relatively pure form. This can be done in standard score form by using the usual multiple regression formulae, and taking the factor loadings for the correlations of the variables with the dependent variable, and the usual intercorrelations for the other needed correlations. The means and standard deviations for the factors may be taken as 0 and 1, respectively. The results will be in terms of standard scores of this sampling. If a mean of 50 and a standard deviation of 10 are taken, the results are in terms of T-scores, which are in some cases more understandable. If this is done, the measurements correlating best with the other factors should be included to partial out the other factors, if the important variables used are loaded with these other factors. To hold plain size of the body constant, these factors might have to be expressed in terms of ratios with the other factors.

With relatively pure measures of these types of growth available, it seems to us that new avenues for research in various fields of anthropometry, medicine, and human biology in general may be opened up.[8]

LITERATURE CITED

(1) Boynton, Bernice: The physical growth of girls. University of Iowa Studies, Studies in Child Welfare, 1936, Vol. 12, No. 4.

(2) Harris, J. A., Jackson, C. M., Paterson, D. Q., and Scammon, R. E.: The measurement of man. Minneapolis, University of Minnesota Press, 1930, Chapter IV.

(3) Hotelling, Harold: Analysis of a complex of statistical variables into principal components. Journal of Educational Psychology, XXIV (1933), 417-441.

(4) Kelley, T. L.: Crossroads in the mind of man. Palo Alto, Stanford University Press, 1928.

(5) McCloy, C. H., Metheny, Eleanor, and Knott, Virginia: A comparison of the Thurstone method of multiple factors with the Hotelling method of principal components. Psychometrika, June, 1938, Vol. 3, No. 2.

(6) Meredith, H. V.: The rhythm of physical growth. University of Iowa Studies, Studies in Child Welfare, 1935, Vol. 11, No. 3.

(7) Spearman, C.: The abilities of man. New York: Macmillan Co., 1927.

(8) Thurstone, L. L.: The vectors of mind. Chicago, University of Chicago Press, 1935.

[8] *An example of such a problem may be found in more specific studies in the field of the effect of variations in endocrine balance on physical growth. This latter type of study should be quite feasible when more accurate methods of measuring the endocrine output have been made available by the physiologists.*

Introduction to Tables 1 to 22

FACTOR LOADINGS OF GROWTH FACTORS

In Tables 1 to 22 given below, the factors may be identified as follows:

Factor I - Growth in fat
Factor II - General growth
Factor III - Growth in cross-section
Factor IV - Not positively identified. Most heavily weighted with measurements of chest dimensions and width of shoulders.
Factor V - Neural growth. Found only in Table 22, females. Measurements germane to this factor were not taken in other groups.

In Tables 1 to 20, the unsmoothed, rotated factor loadings are given at the upper left, while the smoothed rotated factor loadings are underlined at the lower right. In Tables 21 and 22, the factor loadings for males are at the upper left, and the loadings for females are at the lower right and are underlined.

The symbol "h" is the square root of the sum of the squares of the four factor loadings, and is given only for the unsmoothed loadings.

TABLE 1

BOYS - AGE 9 DAYS (N = 50)

	I	II	III	IV	h
1. Weight	.772	.497	.325	.195	.993
	.499	.610	.422	.138	
2. Height	.585	.721	.029	.118	.955
	.305	.806	.015	.081	
3. Sitting height	.620	.635	.121	-.051	.896
	.338	.751	.084	.011	
5. Shoulder width	.644	.289	.565	.261	.835
	.329	.424	.223	.201	
6. Hip	.756	.519	.437	.007	.930
	.445	.457	.388	-.116	
9. Chest girth	.451	.436	.528	.214	.953
	.540	.518	.379	.143	
11. Elbow	.579	.545	.532	.021	.854
	.250	.572	.582	.009	
13. Knee width	.550	.502	.540	-.117	.916
	.387	.516	.499	-.058	
15. Arm	.844	.177	.406	.157	.965
	.612	.400	.365	.045	
16. Forearm	.851	.188	.444	.102	.985
	.647	.241	.587	.034	
17. Thigh	.801	.217	.567	.166	.925
	.567	.282	.524	.111	
18. Calf	.847	.206	.396	.193	.978
	.524	.255	.566	.205	
19. Fat chest front	.862	.065	.225	-.098	.899
	.829	.029	.073	-.091	
20. Fat chest back	.907	-.033	.058	.165	.925
	.841	-.044	.015	-.180	
21. Fat arm front	.865	.010	-.077	.072	.871
	.854	-.065	-.121	.092	
22. Fat arm back	.916	.055	-.061	-.135	.929
	.853	-.065	-.121	.092	

TABLE 2

BOYS - AGE 4 YEARS (N = 69)

	I	II	III	IV	h
1. Weight	.090	.737	.579	.051	.943
	.409	.666	.448	.110	
2. Height	-.057	.910	.101	.010	.918
	.194	.855	.019	.066	
3. Sitting height	-.041	.856	.026	.054	.858
	.247	.777	.077	.032	
5. Shoulder width	-.145	.571	.003	.101	.597
	.252	.503	.194	.185	
6. Hip width	.002	.602	.407	-.415	.837
	.358	.559	.325	-.115	
7. Chest width	.137	.598	.265	-.209	.700
	.132	.511	.380	.049	
8. Chest depth	-.119	.452	.557	.054	.728
	.058	.366	.551	.160	
9. Chest girth	.751	.456	.328	.214	.953
	.463	.521	.454	.185	
11. Elbow width	.041	.512	.781	-.041	.843
	.250	.434	.551	.023	
13. Knee width	.238	.468	.549	-.088	.765
	.321	.562	.422	.008	
15. Arm girth	.230	.771	.219	-.094	.859
	.560	.459	.413	.003	
16. Forearm	.385	.212	.827	-.079	.940
	.560	.316	.627	.017	
17. Thigh	.198	.320	.768	.042	.856
	.517	.325	.572	.067	
18. Calf	.036	.214	.849	.271	.918
	.428	.325	.614	.156	
19. Fat chest front	.786	-.033	-.140	-.078	.803
	.821	.008	-.002	-.022	
20. Fat chest back	.754	-.136	-.019	.308	.808
	.828	-.006	.012	.135	
21. Fat arm front	.808	-.174	-.186	.068	.850
	.807	-.046	-.135	.109	
22. Fat arm back	.746	-.221	-.000	-.556	.848
	.806	-.085	-.135	.109	

TABLE 3

BOYS - AGE 6 YEARS (N = 149)

	I	II	III	IV	h
1. Weight	.365	.787	.451	.114	.976
	.411	.706	.447	.090	
2. Height	.003	.935	-.025	.115	.942
	.124	.902	.030	.051	
3. Sitting height	.060	.834	.078	.147	.853
	.174	.825	.080	.044	
5. Shoulder width	.175	.662	.181	.197	.735
	.186	.577	.185	.188	
6. Hip width	.220	.718	.085	.169	.774
	.267	.638	.257	-.036	
7. Chest width	.053	.390	.590	.365	.797
	.178	.480	.598	.186	
8. Chest depth	.152	.272	.524	.552	.704
	.152	.329	.546	.215	
9. Chest girth	.349	.441	.615	.436	.940
	.417	.505	.490	.286	
11. Elbow width	.095	.685	.232	.093	.735
	.179	.530	.444	.055	
13. Knee width	.530	.502	.540	-.117	.916
	.274	.635	.519	.105	
15. Arm girth	.604	.399	.600	-.055	.941
	.566	.429	.491	-.055	
16. Forearm	.417	.594	.585	.033	.933
	.496	.416	.640	.011	
17. Thigh	.501	.489	.575	.038	.907
	.529	.374	.576	.040	
18. Calf	.371	.624	.561	.055	.919
	.397	.423	.625	.087	
19. Fat chest front	.790	.042	-.050	.151	.807
	.812	-.017	-.059	.056	
20. Fat chest back	.832	.179	-.002	-.132	.861
	.828	.055	.014	.065	
21. Fat arm front	.755	-.095	-.148	.258	.817
	.789	-.065	-.129	.124	
22. Fat arm back	.718	.082	.143	.010	.756
	.788	-.085	-.129	.124	

TABLE 4

BOYS - AGE 8 YEARS (N = 150)

	I	II	III	IV	h
1. Weight	.492	.701	.455	.029	.971
	.427	.693	.457	.033	
2. Height	.160	.928	.002	-.016	.942
	.142	.932	.020	.032	
3. Sitting height	.166	.852	.096	-.013	.874
	.161	.857	.125	.018	
5. Shoulder width	.240	.629	.274	.186	.750
	.167	.554	.266	.179	
6. Hip width	.328	.657	.224	-.147	.782
	.246	.668	.241	.021	
7. Chest width	.345	.434	.525	.386	.748
	.223	.450	.435	.251	
8. Chest depth	.315	.216	.602	.219	.746
	.249	.285	.560	.250	
9. Chest girth	.459	.458	.539	.371	.921
	.396	.482	.540	.319	
11. Elbow width	.206	.565	.379	.080	.714
	.162	.579	.418	-.000	
13. Knee width	.343	.685	.251	.026	.807
	.294	.669	.297	.097	
15. Arm girth	.612	.508	.640	-.056	.939
	.586	.588	.554	-.048	
16. Forearm	.498	.454	.657	.018	.941
	.476	.451	.656	.009	
17. Thigh	.651	.515	.595	-.098	.941
	.577	.575	.571	.026	
18. Calf	.463	.401	.666	-.095	.910
	.417	.455	.625	-.011	
19. Fat chest front	.861	-.104	-.174	.026	.885
	.803	-.058	-.050	.125	
20. Fat chest back	.865	.093	.051	.057	.875
	.820	.088	.050	.027	
21. Fat arm front	.756	-.084	-.114	.046	.751
	.795	-.065	-.097	.117	
22. Fat arm back	.767	-.057	.169	-.149	.800
	.795	-.065	-.097	.117	
10. Breathing capacity	.006	.749	.075	.255	.794
	.067	.719	.130	.172	

TABLE 5

BOYS - AGE 10 YEARS (N = 138)

	I	II	III	IV	h
1. Weight	.667	.611	.337	.119	.972
	.456	.675	.441	-.036	
2. Height	.516	.914	-.005	.017	.968
	.196	.942	.025	.033	
3. Sitting height	.319	.849	.125	-.055	.917
	.158	.855	.168	.012	
5. Shoulder width	.315	.518	.195	.265	.689
	.160	.497	.342	.199	
6. Hip width	.329	.710	.178	.287	.855
	.260	.683	.248	.115	
7. Chest width	.344	.489	.370	.451	.824
	.252	.468	.458	.251	
8. Chest depth	.463	.362	.463	.340	.822
	.311	.296	.547	.278	
9. Chest girth	.532	.506	.395	.455	.950
	.393	.478	.558	.338	
11. Elbow width	.206	.563	.379	.080	.714
	.170	.608	.386	-.008	
13. Knee width	.402	.695	.313	.199	.884
	.256	.684	.304	.071	
15. Arm girth	.751	.553	.494	-.056	.959
	.624	.553	.575	-.018	
16. Forearm	.617	.458	.594	.024	.962
	.471	.484	.648	.008	
17. Thigh	.755	.416	.367	.188	.955
	.635	.386	.520	.051	
18. Calf	.615	.500	.493	.076	.936
	.467	.493	.561	-.022	
19. Fat chest front	.784	-.070	.027	.250	.826
	.799	-.068	.005	.174	
20. Fat chest back	.851	.076	.032	.074	.858
	.815	.118	.096	.020	
21. Fat arm front	.885	.027	-.042	.037	.887
	.851	-.034	-.067	.114	
22. Fat arm back	.861	.218	-.064	-.141	.902
	.851	-.034	-.067	.114	
10. Breathing capacity	.199	.657	.109	.062	.698
	.054	.751	.178	.157	

TABLE 6

BOYS - AGE 12 YEARS (N = 129)

	I	II	III	IV	
1. Weight	.214	.603	.654	-.306	.9
	.380	.687	.471	-.036	
2. Height	.215	.997	.126	.068	1.030
	.178	.956	.045	.027	
3. Sitting height	.033	.757	.409	-.022	.862
	.096	.851	.192	.031	
5. Shoulder width	-.047	.170	.819	.025	.858
	.108	.458	.424	.149	
6. Hip width	.129	.582	.562	.132	.840
	.221	.679	.291	.066	
7. Chest width	.042	.391	.765	-.281	.903
	.203	.511	.485	.164	
8. Chest depth	.185	.188	.702	.174	1.158
	.289	.326	.535	.279	
9. Chest girth	.171	.386	.859	.044	.940
	.326	.495	.605	.295	
11. Elbow width	.095	.591	.492	-.256	.817
	.154	.607	.369	-.026	
13. Knee width	.324	.645	.467	-.171	.875
	.258	.670	.343	-.054	
15. Arm girth	.494	.555	.660	-.095	.894
	.557	.576	.588	.014	
16. Forearm	.332	.421	.751	-.010	.925
	.385	.509	.676	-.021	
17. Thigh	.550	.289	.699	-.210	.947
	.597	.385	.551	.047	
18. Calf	.556	.428	.655	-.254	.895
	.427	.490	.547	-.018	
19. Fat chest front	.715	-.106	.262	.308	.828
	.796	-.054	.045	.149	
20. Fat chest back	.693	.143	.261	-.116	.765
	.792	.126	.140	.040	
21. Fat arm front	.858	-.022	.035	.259	.897
	.851	-.048	-.055	.107	
22. Fat arm back	.874	-.034	-.030	-.055	.877
	.851	-.049	-.055	.107	
10. Breathing capacity	-.020	.760	.463	.091	.894
	.029	.761	.245	.119	

TABLE 7

BOYS - AGE 14 YEARS (N = 141)

	I	II	III	IV	h
1. Weight	.314	.848	.347	.154	.981
	.351	.700	.485	.007	
2. Height	.060	.949	.010	.023	.951
	.119	.947	.038	.051	
3. Sitting height	.008	.894	.053	.196	.916
	.096	.851	.192	.051	
5. Shoulder width	-.063	.657	.124	.290	.752
	.076	.498	.377	.160	
6. Hip width	.216	.818	.041	.020	.847
	.207	.685	.253	.007	
7. Chest width	.252	.703	.249	.397	.876
	.206	.546	.454	.248	
8. Chest depth	.255	.511	.403	.342	.778
	.292	.357	.475	.293	
9. Chest girth	.329	.655	.467	.412	.962
	.326	.495	.605	.295	
11. Elbow width	.052	.603	.166	.589	.738
	.117	.602	.316	.027	
13. Knee width	.294	.685	.220	-.061	.779
	.227	.572	.351	-.041	
15. Arm girth	.552	.498	.489	.273	.951
	.506	.364	.604	.080	
16. Forearm	.311	.699	.665	-.050	1.015
	.315	.527	.689	-.030	
17. Thigh	.591	.530	.420	.250	.927
	.572	.384	.555	.083	
18. Calf	.350	.657	.569	.220	.859
	.390	.469	.518	.061	
19. Fat chest front	.897	-.026	-.157	.003	.911
	.814	-.027	.040	.072	
20. Fat chest back	.842	.178	.050	.209	.887
	.795	.101	.148	.069	
21. Fat arm front	.883	-.078	-.169	.050	.904
	.854	-.081	-.070	.074	
22. Fat arm back	.811	-.092	.084	-.185	.841
	.854	-.081	.070	.075	
10. Breathing capacity	-.092	.848	.128	.101	.868
	.011	.745	.263	.138	

TABLE 8

BOYS - AGE 16 YEARS (N = 107)

	I	II	III	IV	h
1. Weight	.313	.759	.512	.025	.968
	.361	.651	.552	.023	
2. Height	.063	.958	.014	.001	.960
	.065	.925	.032	.032	
3. Sitting height	-.058	.866	.047	.075	.872
	.000	.758	.104	.067	
5. Shoulder width	.151	.635	.452	-.117	.802
	.100	.505	.365	.161	
6. Hip width	.181	.646	.270	-.268	.772
	.211	.644	.265	-.079	
7. Chest width	.200	.607	.511	.276	.864
	.235	.509	.451	.356	
8. Chest depth	.296	.418	.360	.407	.747
	.322	.512	.447	.268	
9. Chest girth	.256	.520	.661	.416	.967
	.332	.415	.608	.386	
11. Elbow width	.089	.673	.248	-.192	.748
	.141	.577	.316	.078	
13. Knee width	.284	.656	.370	-.159	.815
	.268	.523	.335	-.015	
15. Arm girth	.317	.414	.709	-.032	.861
	.458	.271	.665	.103	
16. Forearm	.117	.592	.660	-.125	.905
	.268	.460	.717	-.015	
17. Thigh	.444	.395	.696	.072	.918
	.562	.309	.589	.093	
18. Calf	.385	.410	.577	.102	.812
	.367	.354	.547	.095	
19. Fat chest front	.800	.126	.052	-.111	.819
	.818	-.021	.071	-.003	
20. Fat chest back	.799	.104	.165	.086	.826
	.796	.026	.163	.055	
21. Fat arm front	.807	-.187	-.045	-.036	.851
	.833	-.116	-.068	.038	
22. Fat arm back	.819	-.080	.065	-.185	.846
	.835	-.116	-.068	.038	
10. Breathing capacity	.103	.808	.250	.220	.880
	.015	.660	.312	.191	

TABLE 9

BOYS - COLLEGE AGE (N = 336)

	I	II	III	IV	h
1. Weight	.489	.430	.701	.043	
	.411	.586	.598	.049	.958
2. Height	.019	.852	.033	.056	
	.039	.898	.024	.034	.855
3. Sitting height	.042	.561	.089	.004	
	.005	.700	.075	.049	.570
5. Shoulder width	.134	.385	.287	.398	
	.118	.499	.324	.214	.638
6. Hip width	.264	.546	.309	-.014	
	.231	.610	.266	-.095	.681
7. Chest width	.351	.320	.421	.619	
	.276	.458	.452	.480	.879
8. Chest depth	.438	.117	.479	.112	
	.371	.261	.431	.236	.669
9. Chest girth	.484	.154	.571	.451	
	.384	.332	.590	.435	.888
11. Elbow width	.268	.459	.426	.038	
	.184	.546	.338	.000	.682
13. Knee width	.235	.245	.332	.211	
	.251	.480	.332	.057	.519
15. Arm girth	.524	-.045	.739	.191	
	.458	.169	.701	.126	.927
16. Forearm	.370	.182	.800	.120	
	.279	.376	.737	.020	.908
17. Thigh	.671	.083	.560	.124	
	.586	.237	.590	.119	.886
18. Calf	.564	.075	.601	.121	
	.370	.250	.567	.126	.717
19. Fat chest front	.819	-.138	.178	-.005	
	.821	-.037	.099	-.038	.849
20. Fat chest back	.796	-.191	.205	-.022	
	.802	-.052	.174	.040	.844
21. Fat arm front	.817	-.100	-.089	.052	
	.821	-.127	-.067	.011	.826
22. Fat arm back	.704	-.175	-.120	-.009	
	.821	-.127	-.067	.011	.735
10. Breathing capacity	.009	.354	.448	.254	
	.029	.560	.346	.226	.625

TABLE 10

GIRLS - AGE 9 DAYS (N = 50)

	I	II	III	IV	h
1. Weight	.520	.685	.393	.271	
	.464	.707	.387	.293	.984
2. Height	.295	.905	-.003	.016	
	.207	.918	-.030	.015	.952
3. Sitting height	.277	.852	.256	.007	
	.167	.885	.180	.044	.927
5. Shoulder width	.179	.302	.603	.204	
	.186	.436	.414	.287	.727
6. Hip width	.289	.268	.574	.022	
	.295	.428	.374	.253	.697
9. Chest girth	.507	.466	.400	.419	
	.493	.445	.454	.384	.899
11. Elbow width	.300	.411	.486	.163	
	.253	.481	.507	.075	.722
13. Knee width	.212	.342	.599	-.012	
	.303	.467	.415	.127	.722
15. Arm girth	.604	.303	.642	.226	
	.551	.280	.656	.165	.959
16. Forearm	.484	.423	.656	.183	
	.479	.426	.651	.155	.937
17. Thigh	.637	.317	.546	-.008	
	.587	.397	.527	.134	.897
18. Calf	.671	.295	.539	.275	
	.515	.418	.560	.191	.950
19. Fat chest front	.689	.134	.268	-.111	
	.732	.042	.095	.034	.759
20. Fat chest back	.754	.070	.244	-.230	
	.779	.078	.138	-.108	.828
21. Fat arm front	.747	-.009	-.252	.252	
	.743	.041	-.166	.156	.827
22. Fat arm back	.707	-.041	.104	.286	
	.639	.029	.172	.133	.771

TABLE 11

GIRLS - AGE 4 YEARS (N = 70)

	I	II	III	IV	h
1. Weight	.410 .504	.758 .704	.545 .408	.373 .260	.985
2. Height	.084 .182	.933 .822	-.093 -.033	.018 .033	.941
3. Sitting height	-.014 .156	.928 .895	.120 .140	.127 .056	.944
5. Shoulder width	.144 .224	.627 .487	.182 .306	.407 .281	.778
6. Hip width	.307 .295	.608 .428	.115 .374	.509 .253	.858
7. Chest width	.128 .205	.445 .499	.577 .465	.470 .483	.876
8. Chest depth	.344 .512	.126 .227	.612 .491	.256 .320	.751
9. Chest girth	.506 .495	.347 .455	.564 .451	.445 .321	.944
11. Elbow width	.210 .269	.584 .489	.570 .465	-.095 .075	.848
13. Knee width	.441 .350	.621 .518	.190 .514	.307 .168	.843
15. Arm girth	.478 .557	.218 .287	.661 .643	.087 .126	.849
16. Forearm	.482 .504	.427 .418	.687 .603	.085 .156	.945
17. Thigh	.527 .585	.398 .370	.514 .506	.387 .152	.922
18. Calf	.276 .472	.567 .475	.609 .557	.071 .149	.880
19. Fat chest front	.763 .768	-.116 .037	-.186 .009	.151 .053	.808
20. Fat chest back	.815 .789	.097 .075	-.009 .149	.054 -.055	.822
21. Fat arm front	.722 .738	.093 .063	.004 -.165	.010 .118	.728
22. Fat arm back	.452 .659	-.017 .040	.292 .185	-.087 .086	.546

TABLE 12

GIRLS - AGE 6 YEARS (N = 110)

	I	II	III	IV	h
1. Weight	.343 .503	.720 .694	.482 .436	.159 .192	.945
2. Height	.141 .157	.940 .925	.021 -.030	-.002 .067	.951
3. Sitting height	.155 .148	.898 .894	.082 .099	-.018 .048	.915
5. Shoulder width	.347 .274	.537 .546	.225 .187	.346 .259	.761
6. Hip width	.287 .351	.684 .600	.144 .206	.641 .411	.991
7. Chest width	.245 .263	.600 .517	.510 .430	.533 .447	.895
8. Chest depth	.190 .347	.367 .271	.521 .459	.487 .316	.714
9. Chest girth	.591 .504	.633 .480	.397 .445	.025 .230	.844
11. Elbow width	.145 .262	.520 .501	.419 .396	.144 .056	.698
13. Knee width	.348 .376	.629 .576	.173 .228	.278 .227	.790
15. Arm girth	.501 .584	.350 .298	.717 .623	.094 .081	.947
16. Forearm	.442 .539	.440 .394	.516 .555	.226 .128	.840
17. Thigh	.518 .601	.555 .410	.472 .476	.084 .118	.897
18. Calf	.429 .455	.589 .514	.521 .545	.139 .081	.907
19. Fat chest front	.852 .825	.055 .024	.075 -.050	.124 .047	.866
20. Fat chest back	.795 .807	.055 .049	.247 .160	.018 .025	.855
21. Fat arm front	.792 .742	.140 .074	-.252 -.161	.118 .062	.851
22. Fat arm back	.861 .715	.120 .054	.156 .175	.051 .059	.883

TABLE 13

GIRLS - AGE 8 YEARS (N = 102)

	I	II	III	IV	h
1. Weight	.540	.628	.494	.088	.968
	.542	.671	.456	.121	
2. Height	.221	.903	-.057	.196	.952
	.144	.819	-.013	.154	
3. Sitting height	.517	.897	.027	-.027	.952
	.154	.887	.070	.051	
5. Shoulder width	.349	.519	.009	.005	.625
	.292	.587	.116	.136	
6. Hip width	.434	.536	.180	.340	.790
	.355	.654	.185	.342	
7. Chest width	.456	.464	.353	.402	.842
	.317	.534	.421	.396	
8. Chest depth	.524	.515	.399	.238	.767
	.414	.503	.442	.302	
9. Chest girth	.641	.591	.372	.249	.874
	.527	.462	.458	.230	
10. Breathing capacity	.055	.623	.307	.199	.732
	.030	.630	.305	.053	
11. Elbow width	.602	.379	.182	.188	.758
	.276	.498	.339	.032	
13. Knee width	.498	.515	.108	.068	.727
	.395	.576	.213	.234	
15. Arm girth	.764	.320	.442	.004	.939
	.640	.292	.587	.041	
16. Forearm	.749	.329	.368	.148	.909
	.576	.345	.600	.005	
17. Thigh	.738	.436	.431	.061	.961
	.641	.415	.460	.073	
18. Calf	.552	.510	.526	.033	.918
	.470	.506	.548	.011	
19. Fat chest front	.853	-.046	-.318	-.033	.912
	.868	.021	-.301	.042	
20. Fat chest back	.799	.058	.238	.177	.854
	.829	.040	.169	.048	
21. Fat arm front	.656	.051	-.236	.036	.698
	.725	.051	-.224	.027	
22. Fat arm back	.729	.093	.166	.115	.762
	.726	.084	.162	.041	

TABLE 14

GIRLS - AGE 10 YEARS (N = 124)

	I	II	III	IV	h
1. Weight	.555	.666	.405	.056	.959
	.532	.653	.458	.071	
2. Height	.085	.951	-.036	.166	.960
	.133	.914	-.000	.150	
3. Sitting height	.118	.852	.015	.111	.867
	.141	.869	.068	.024	
5. Shoulder width	.260	.706	.059	.083	.759
	.282	.605	.149	.092	
6. Hip width	.345	.790	.254	.054	.900
	.360	.703	-.209	.212	
7. Chest width	.332	.595	.500	.214	.872
	.326	.556	.443	.360	
8. Chest depth	.474	.328	.538	.195	.815
	.466	.320	.449	.268	
9. Chest girth	.561	.485	.539	.186	.935
	.525	.448	.476	.275	
10. Breathing capacity	.002	.619	.519	-.277	.749
	.099	.651	.278	.059	
11. Elbow width	.187	.495	.398	-.205	.692
	.224	.494	.366	.005	
13. Knee width	.251	.680	.337	.468	.926
	.385	.538	.288	.226	
15. Arm girth	.664	.251	.612	.056	.937
	.653	.287	.572	.027	
16. Forearm	.578	.294	.665	-.172	.945
	.576	.345	.600	.005	
17. Thigh	.688	.395	.436	-.081	.909
	.661	.454	.458	.018	
18. Calf	.484	.409	.532	-.168	.844
	.498	.462	.561	-.037	
19. Fat chest front	.951	.025	.066	.025	.954
	.891	.020	-.060	.030	
20. Fat chest back	.895	-.101	.111	-.077	.911
	.854	.036	.187	.026	
21. Fat arm front	.801	.006	.021	-.139	.81
	.710	.032	-.074	.026	
22. Fat arm back	.769	.015	.067	.015	.77
	.735	.043	.155	.016	

TABLE 15

GIRLS - AGE 12 YEARS (N = 151)

	I	II	III	IV	h
1. Weight	.533	.649	.499	.157	.986
	.565	.605	.481	.091	
2. Height	.100	.888	.007	.267	.932
	.123	.895	.010	.141	
3. Sitting height	.172	.864	.028	.059	.884
	.134	.844	.085	.018	
5. Shoulder width	.227	.618	.283	-.050	.718
	.292	.563	.186	.120	
6. Hip width	.324	.719	.219	.159	.854
	.351	.700	.244	.134	
7. Chest width	.201	.584	.529	.392	.903
	.304	.515	.458	.406	
8. Chest depth	.480	.271	.455	.404	.821
	.494	.302	.456	.262	
9. Chest girth	.410	.404	.571	.454	.929
	.498	.385	.478	.400	
10. Breathing capacity	-.017	.697	.250	.519	.807
	.054	.650	.241	.149	
11. Elbow width	.179	.488	.464	.086	.702
	.224	.471	.454	.044	
13. Knee width	.420	.398	.379	.100	.699
	.415	.460	.368	.139	
15. Arm girth	.663	.250	.639	.010	.954
	.642	.257	.561	.051	
16. Forearm	.472	.596	.727	.008	.955
	.549	.519	.657	.020	
17. Thigh	.619	.489	.520	.079	.948
	.647	.430	.496	.038	
18. Calf	.470	.464	.636	.018	.917
	.498	.402	.607	-.032	
19. Fat chest front	.885	.075	-.054	.228	.918
	.874	.026	-.059	.086	
20. Fat chest back	.866	.178	.219	-.037	.911
	.873	.074	.185	.048	
21. Fat arm front	.650	-.019	.055	.164	.673
	.673	.038	-.007	.050	
22. Fat arm back	.638	.044	.187	-.155	.684
	.695	.025	.142	-.043	

TABLE 16

GIRLS - AGE 13 YEARS (N = 164)

	I	II	III	IV	h
1. Weight	.633	.605	.438	.090	.983
	.591	.550	.518	.129	
2. Height	.164	.915	.013	-.075	.932
	.102	.867	.004	.078	
3. Sitting height	.180	.840	.066	-.166	.878
	.110	.803	.126	.026	
5. Shoulder width	.260	.499	.353	.325	.739
	.256	.491	.186	.202	
6. Hip width	.405	.762	.179	.104	.888
	.327	.669	.292	.115	
7. Chest width	.378	.523	.413	.475	.902
	.307	.456	.426	.469	
8. Chest depth	.576	.358	.396	.055	.787
	.486	.273	.430	.283	
9. Chest girth	.551	.355	.386	.489	.904
	.484	.359	.599	.485	
10. Breathing capacity	.159	.735	.124	.138	.775
	.120	.608	.186	.193	
11. Elbow width	.304	.339	.628	.188	.793
	.222	.440	.484	.137	
13. Knee width	.551	.345	.429	.012	.765
	.421	.380	.461	.061	
15. Arm girth	.659	.279	.583	.157	.933
	.620	.215	.555	.126	
16. Forearm	.567	.334	.699	.022	.960
	.526	.274	.671	.107	
17. Thigh	.654	.498	.422	.042	.925
	.632	.387	.539	.063	
18. Calf	.559	.397	.609	-.056	.918
	.497	.320	.644	.007	
19. Fat chest front	.840	-.006	-.067	.076	.846
	.847	.024	.011	.099	
20. Fat chest back	.874	.100	.130	.165	.904
	.878	.081	.185	.078	
21. Fat arm front	.580	.108	-.112	.137	.61[illegible]
	.660	.046	-.007	.047	
22. Fat arm back	.691	-.053	.097	-.121	.70[illegible]
	.689	.008	.137	-.045	

TABLE 17

GIRLS - AGE 15 YEARS (N = 136)

	I	II	III	IV	h
1. Weight	.574 .600	.325 .427	.654 .567	.258 .210	.965
2. Height	.088 .074	.780 .834	.003 -.001	.086 .082	.789
3. Sitting height	.041 .099	.723 .759	.280 .168	.118 .085	.785
5. Shoulder width	.257 .266	.285 .388	-.007 .112	.414 .254	.564
6. Hip width	.249 .290	.496 .581	.495 .346	.073 .167	.747
7. Chest width	.260 .306	.187 .359	.351 .397	.699 .535	.845
8. Chest depth	.382 .420	.215 .202	.474 .419	.413 .367	.766
9. Chest girth	.586 .448	.180 .240	.323 .324	.642 .566	.835
10. Breathing capacity	.157 .144	.251 .548	.251 .157	.470 .264	.602
11. Elbow width	.264 .251	.485 .435	.440 .486	.171 .218	.726
13. Knee width	.416 .408	.384 .320	.532 .525	-.079 -.012	.781
15. Arm girth	.635 .640	.055 .151	.604 .534	.326 .229	.936
16. Forearm	.484 .496	.099 .202	.640 .639	.510 .208	.866
17. Thigh	.542 .628	.181 .256	.749 .600	.128 .118	.950
18. Calf	.434 .467	.106 .228	.749 .682	.067 .067	.874
19. Fat chest front	.782 .812	.022 .016	.127 .026	.220 .110	.822
20. Fat chest back	.926 .865	.073 .057	.270 .177	.190 .116	.986
21. Fat arm front	.690 .660	.159 .046	-.002 -.007	-.038 .047	.707
22. Fat arm back	.690 .686	.080 -.017	.184 .139	.012 .001	.719

TABLE 18

GIRLS - AGE 16 YEARS (N = 113)

	I	II	III	IV	h
1. Weight	.656 .589	.338 .388	.657 .590	.162 .243	.988
2. Height	-.054 .037	.797 .830	.009 -.005	.058 .095	.800
3. Sitting height	.042 .074	.682 .732	.204 .175	.270 .126	.762
5. Shoulder width	.296 .252	.414 .354	.005 .084	.030 .258	.510
6. Hip width	.257 .239	.516 .521	.409 .350	.206 .201	.730
7. Chest width	.370 .325	.400 .325	.331 .401	.403 .510	.754
8. Chest depth	.445 .384	.084 .148	.284 .418	.559 .422	.773
9. Chest girth	.555 .426	.208 .199	.110 .306	.517 .585	.792
10. Breathing capacity	.322 .140	.707 .549	.058 .149	.027 .235	.780
11. Elbow width	.197 .201	.381 .422	.351 .447	.490 .243	.740
13. Knee width	.272 .365	.139 .297	.702 .571	.003 -.029	.765
15. Arm girth	.728 .649	.026 .090	.408 .530	.386 .271	.920
16. Forearm	.542 .454	.178 .171	.539 .632	.432 .226	.895
17. Thigh	.718 .631	.076 .145	.614 .620	.109 .145	.954
18. Calf	.504 .432	.156 .194	.666 .687	.164 .085	.862
19. Fat chest front	.820 .777	.020 .004	.089 .024	-.059 .065	.827
20. Fat chest back	.805 .854	.025 .016	.185 .159	-.072 .121	.829
21. Fat arm front	.721 .698	-.179 -.010	-.055 -.037	-.066 -.065	.748
22. Fat arm back	.706 .699	-.030 -.052	.112 .115	.181 .052	.758

TABLE 19

GIRLS - AGE 17 YEARS (N = 97)

	I	II	III	IV	h
1. Weight	.570 .536	.335 .409	.493 .601	.475 .272	.952
2. Height	.038 .020	.857 .846	-.069 -.004	.250 .129	.896
3. Sitting height	.152 .056	.755 .733	.108 .154	.147 .106	.792
5. Shoulder width	.288 .251	.197 .350	.028 .124	.382 .284	.518
6. Hip width	.257 .275	.468 .477	.234 .519	.502 .200	.769
7. Chest width	.296 .517	.237 .306	.505 .444	.567 .481	.849
8. Chest depth	.114 .273	.118 .125	.535 .461	.438 .438	.709
9. Chest girth	.257 .365	.088 .188	.387 .394	.702 .592	.846
10. Breathing capacity	-.022 .080	.591 .536	.138 .196	.321 .235	.688
11. Elbow width	.111 .165	.550 .412	.456 .462	.042 .182	.709
13. Knee width	.402 .342	.562 .334	.484 .567	.001 -.051	.726
15. Arm girth	.681 .625	.024 .095	.479 .566	.273 .237	.877
16. Forearm	.325 .373	.105 .175	.627 .679	.024 .154	.714
17. Thigh girth	.665 .592	-.053 .126	.562 .637	.306 .163	.924
18. Calf girth	.306 .374	.202 .218	.707 .689	.123 .068	.806
19. Fat chest front	.760 .725	-.024 .007	-.140 .001	.068 .072	.777
20. Fat chest back	.762 .816	-.131 .001	-.081 .102	.325 .151	.841
21. Fat arm front	.692 .727	-.041 -.008	-.011 -.028	-.208 -.100	.724
22. Fat arm back	.674 .711	-.270 -.065	.096 .088	.083 -.007	.737

TABLE 20

GIRLS - COLLEGE AGE (N = 306)

	I	II	III	IV	h
1. Weight	.410 .491	.557 .465	.667 .606	.147 .258	.972
2. Height	.015 .017	.889 .868	.049 .005	.070 .128	.894
3. Sitting height	-.024 .042	.748 .743	.126 .128	.038 .051	.760
5. Shoulder width	.125 .197	.483 .380	.343 .200	.313 .305	.681
6. Hip width	.321 .290	.435 .466	.285 .281	-.064 .155	.614
7. Chest width	.321 .518	.352 .319	.489 .477	.376 .441	.779
8. Chest depth	.282 .244	.155 .135	.503 .489	.368 .412	.702
9. Chest girth	.340 .336	.275 .206	.613 .482	.516 .578	.915
10. Breathing capacity	-.033 .051	.396 .539	.357 .259	.309 .249	.606
11. Elbow width	.185 .150	.291 .381	.549 .496	.120 .135	.654
13. Knee width	.304 .333	.418 .369	.573 .558	-.130 -.071	.782
15. Arm girth	.497 .584	.226 .114	.746 .620	.073 .174	.928
16. Forearm	.273 .320	.271 .205	.857 .734	.045 .081	.922
17. Thigh girth	.453 .553	.321 .169	.697 .639	.070 .155	.894
18. Calf girth	.356 .345	.326 .264	.666 .680	-.093 .036	.820
19. Fat chest front	.606 .681	-.018 -.016	.042 -.013	.114 .060	.619
20. Fat chest back	.840 .806	.086 .007	.154 .066	.112 .162	.865
21. Fat arm front	.780 .744	.099 -.034	-.036 -.029	.035 -.096	.788
22. Fat arm back	.757 .724	.055 -.063	.043 .068	-.098 -.007	.766

TABLE 21

FACTOR LOADINGS FOR BOYS (N = 32,165) AND GIRLS (N = 31,919) FROM THE BUREAU OF HOME ECONOMICS GARMENT STUDY. BOYS' FACTOR LOADINGS ARE IN ROMAN TYPE AT THE UPPER LEFT, AND GIRLS' FACTOR LOADINGS ARE UNDERLINED AT THE LOWER RIGHT

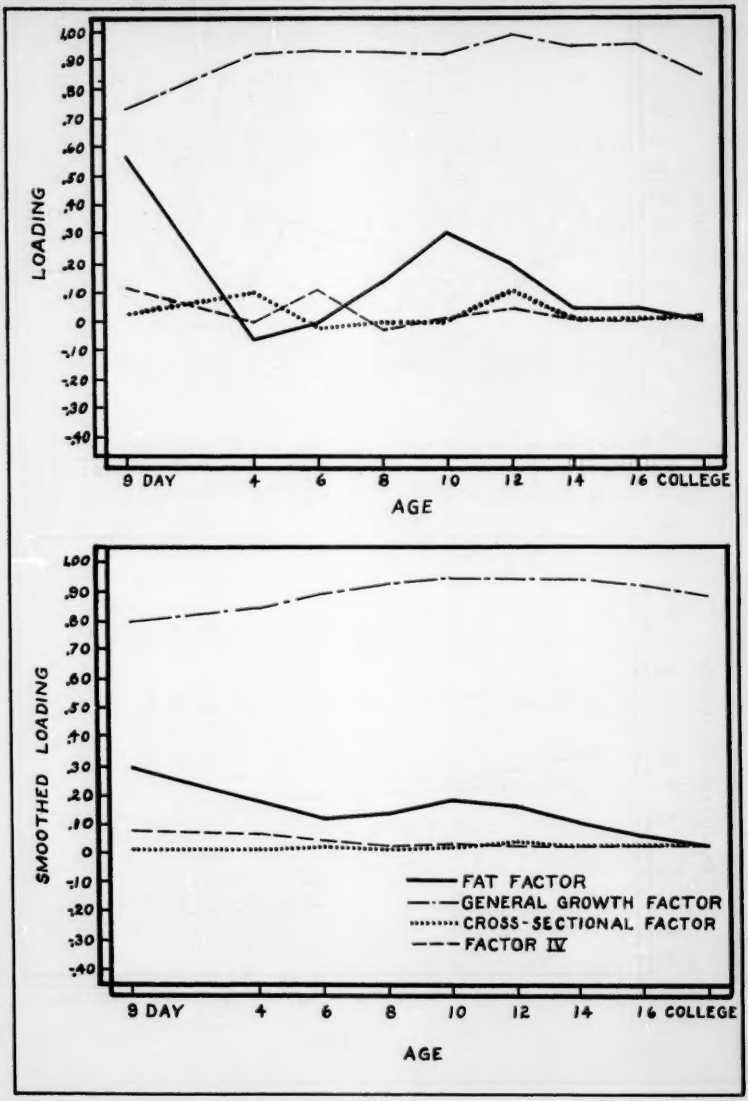
	II (General Growth Facta)	III (Cross Sectional Facta)	h
1. Height	.996 .997	.056 .044	.997 .998
2. Height cervicale	.997 .997	.033 .047	.997 .998
3. Height waist	.997 .996	.012 .038	.997 .997
4. Height hips	.994 .990	-.019 -.000	.994 .990
5. Height tibiale	.982 .977	.001 .019	.982 .977
6. Length left arm posterior	.981 .980	.042 .061	.982 .982
7. Crotch length	.893 .884	.307 .341	.944 .947
8. Girth trunk vertically	.926 .933	.295 .280	.972 .974
9. Weight	.997 .893	.012 .429	.997 .991
10. Hip width, bitrochanteric	.907 .897	.345 .375	.971 .972
11. Girth neck base	.848 .849	.500 .502	.899 .901
12. Girth chest scye	.885 .862	.390 .444	.967 .969
13. Girth waist	.776 .727	.505 .563	.926 .920
14. Girth hips	.890 .880	.431 .455	.989 .990
15. Girth arm scye	.892 .886	.342 .392	.956 .969
16. Girth upper arm	.763 .730	.569 .611	.952 .952
17. Girth thigh	.816 .805	.520 .557	.967 .979
18. Girth knee (tibiale)	.902 .879	.334 .391	.962 .962
19. Girth calf	.863 .840	.419 .459	.959 .196

TABLE 22

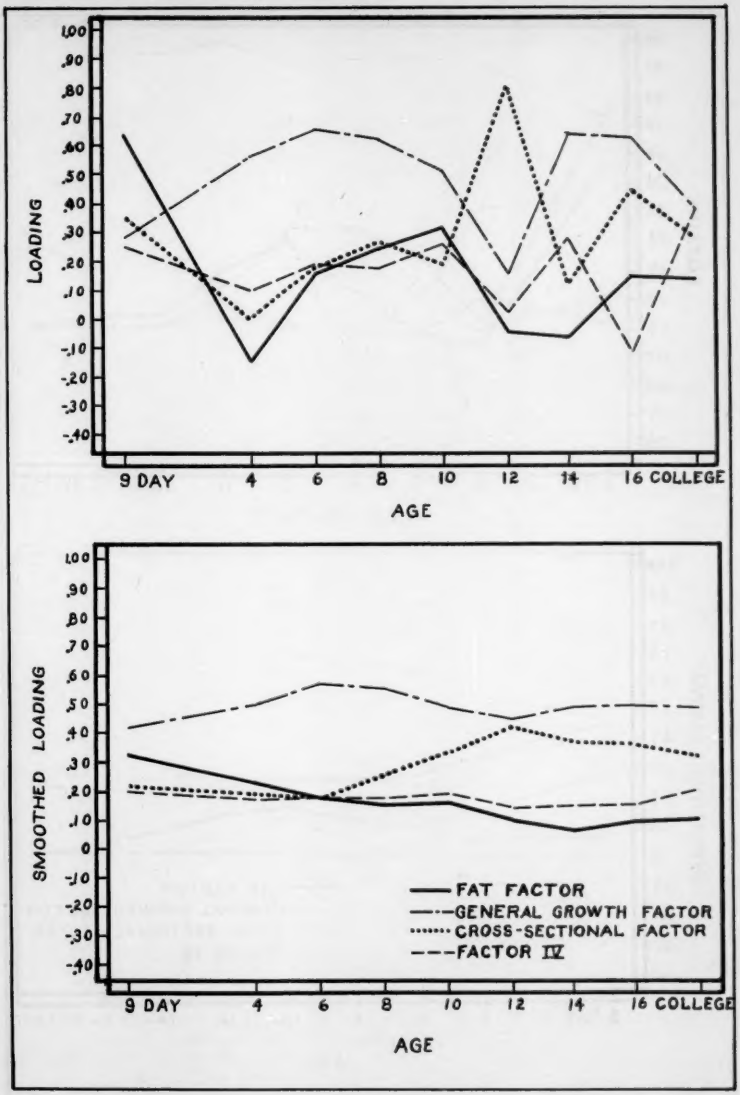
FACTOR LOADINGS OF GROWTH FACTORS OF COLLEGE MEN (N = 200) AND COLLEGE WOMEN (N = 700). LOADINGS FOR MEN ARE IN ROMAN TYPE AT UPPER LEFT, AND LOADINGS FOR WOMEN ARE UNDERLINED AT LOWER RIGHT

	I	II	III	IV	V	h
1. Weight	.658	.418	.570	.140		.976
	.709	.547	.517	.246	.142	.985
2. Height	.070	.851	.152	.085		.868
	-.039	.990	.057	.095	.290	1.038
3. Sitting height	.169	.770	.569	-.013	-	.867
4. Sitting height to cervicle	.130	.803	-.073	.091	.070	.825
5. L. cervicle to lumbale	-.001	.251	.170	.256		.384
	-.104	.480	.443	-.149	-.074	.682
6. L. sternum	.298	.315	.405	.103		.602
	.222	.352	.216	-.158	-.191	.550
7. L. upper arm	.108	.670	.099	.066		.689
	.264	.774	.125	-.216	.017	.855
8. L. forearm	.033	.261	.046	-.095		.285
	.127	.655	.003	-.020	.365	.744
9. L. head	.000	.257	.100	-.051		.281
	.057	.675	.254	.010	.186	.747
10. L. tibia	.075	.667	-.008	.002		.671
	.151	.825	-.056	-.208	.041	.867
11. L. foot	.150	.767	.251	-.009		.615
	.154	.848	.281	.148	.172	.758
12. L. clavicle	-.005	.523	.143	.655		.742
	.116	.611	.229	.096	-.151	.681
13. L. clavicle including acromion	.180	.354	.275	.650		.810
	.209	.663	.325	.111	-.161	.800
14. L. 10th rib	.340	.257	.402	.022		.577
	.520	.582	.230	-.199	-.184	.736
15. W. shoulders	.180	.288	.359	.381		.624
	.250	.516	.240	.336	-.068	.710
16. W. hips iliocristale	.419	.467	.457	-.137		.788
	.212	.095	.221	.056	.071	.535
17. W. hips iliospinale anterior	.420	.398	.261	-.168		.656
	.244	.352	.041	.008	.002	.430
18. W. ilium top	.435	.364	.079	.046		.574
	.460	.399	.282	.306	.259	.761
19. W. elbow	.222	.485	.480	-.061		.719
	.494	.288	.457	.003	-.087	.787
20. W. knee	.178	.550	.085	.002		.401
	.464	.239	.581	.135	-.028	.795
21. D. chest	.615	.191	.411	.137		.776
	.726	.199	.231	.074	.196	.815
22. W. chest	.464	.285	.571	.034		.789
	.523	.237	.266	.510	.125	.822
23. G. chest	.594	.270	.620	.061		.902
	.730	.265	.219	.518	.154	.881
24. G. neck	.363	.255	.600	.087		.741
	.624	.135	.252	.146	.104	.709
25. G. arm	.611	.122	.665	.070		.914
	.776	-.025	.446	.240	.038	.828
26. G. forearm	.406	.355	.680	.106		.866
	.658	.169	.575	.214	.047	.816
27. G. thigh	.726	.257	.592	.162		.875
	.670	.124	.519	.167	.119	.880
28. G. calf	.427	.321	.445	.095		.700
	.581	-.076	.675	.116	-.088	.905
29. Breathing capacity	.134	.394	.501	.106		.660
	.187	.511	.501	.231	.078	.668
30. Fat chest front	.914	.023	-.071	-.069		.920
	.874	.059	-.052	.056	-.178	.897
31. Fat chest back	.882	.006	.092	.039		.888
	.825	.015	.051	-.077	-.242	.865
32. Fat abdomen	.909	-.001	-.017	-.030		.910
	.860	.052	-.068	.201	-.060	.889
33. Fat suprailiac	.888	.001	-.081	.038		.895
	.780	.019	-.011	.048	-.117	.780
34. Porion-opisthocranion	-.016	.044	-.100	.059	.680	.681
35. Porion-nasion	.188	.151	.090	-.057	.757	.787
36. Porion-subnasale	.206	.094	-.006	.128	.829	.869
37. Costal angle, mid-respiration	.164	-.249	-.007	.806	.416	.795
38. Costal angle, inspiration	.089	-.258	.087	.572	.379	.750

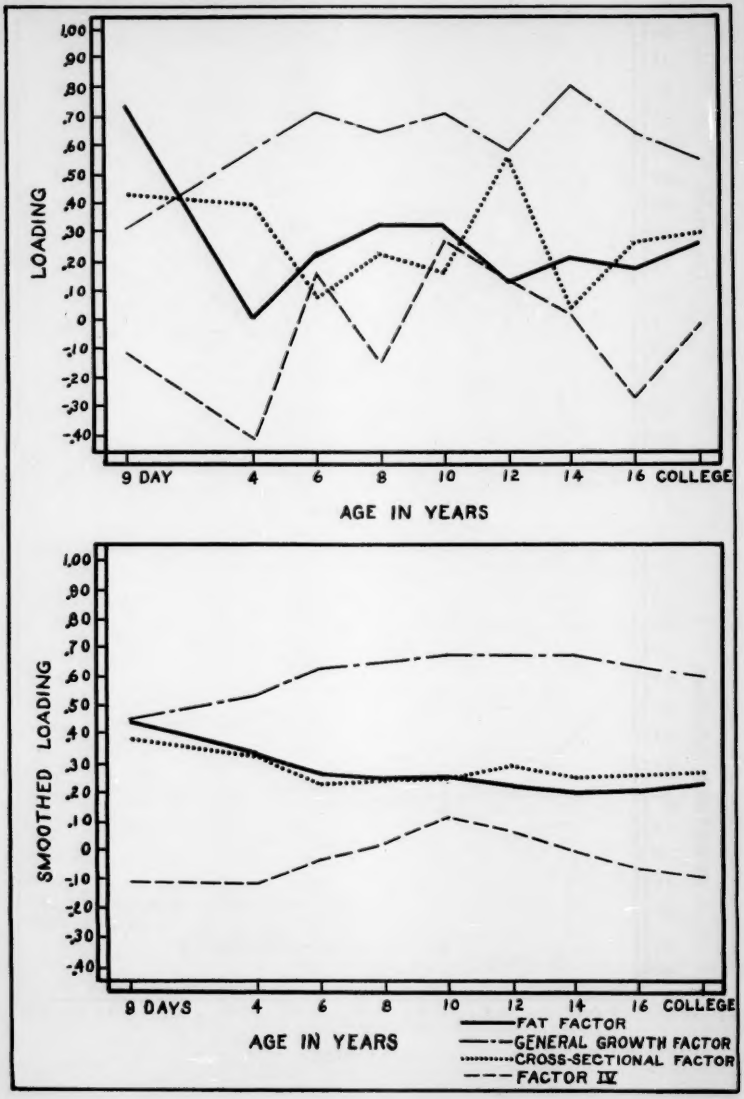
HEIGHT (MALES)



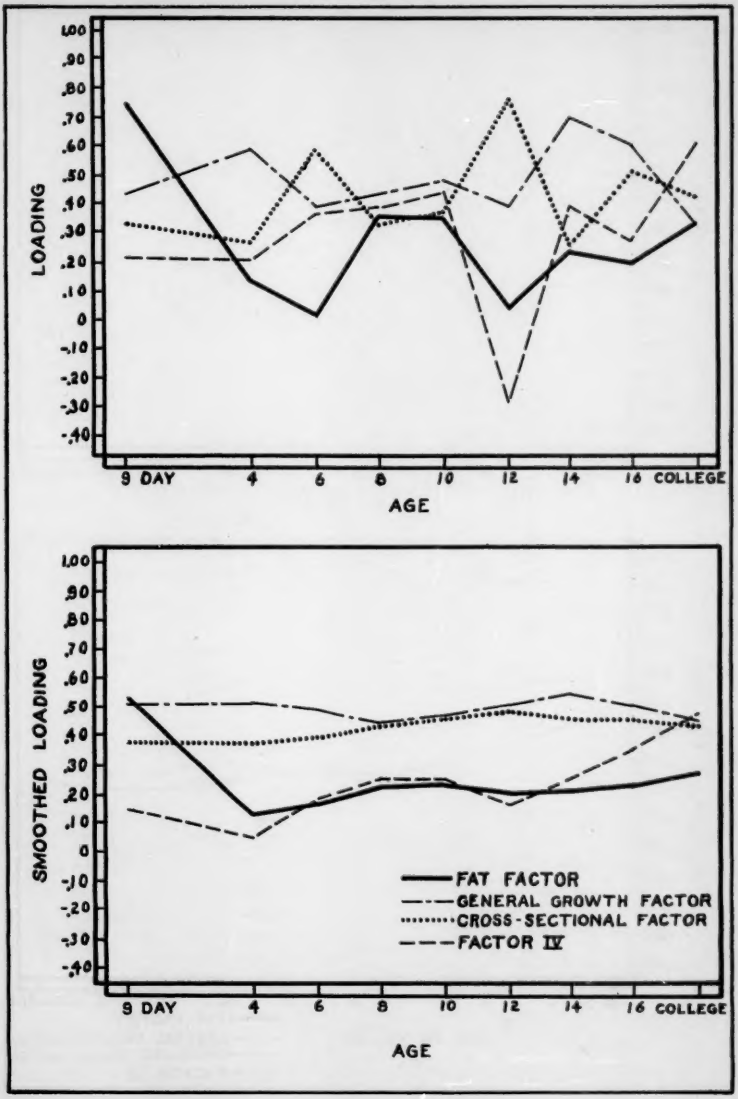
SHOULDER WIDTH (MALES)



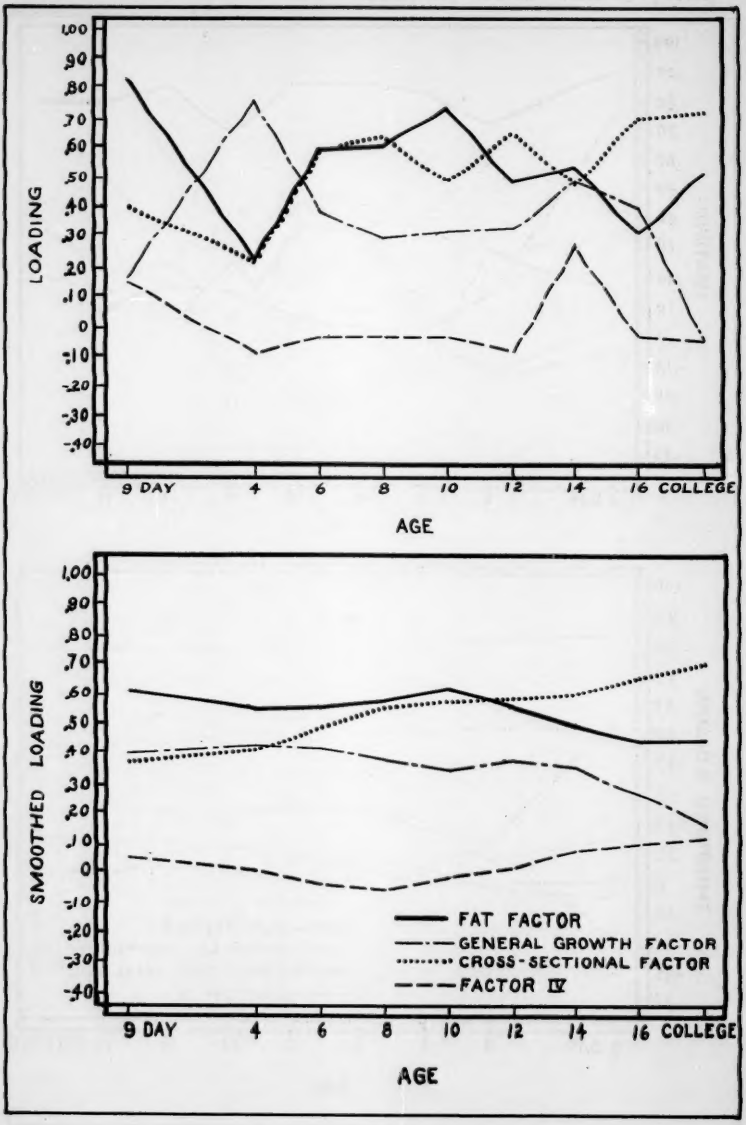
HIP WIDTH (MALES)



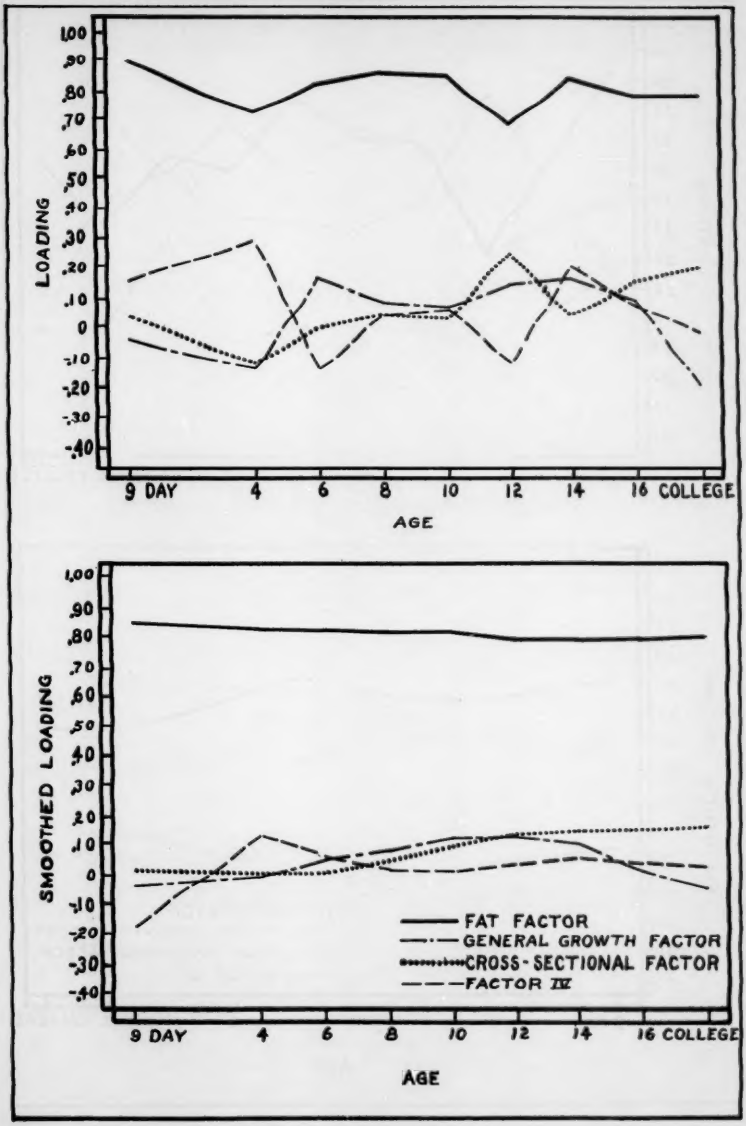
CHEST GIRTH (MALES)



UPPER ARM GIRTH (MALES)



FAT, CHEST BACK (MALES)



TREND IN THE STUDY OF PHYSICAL GROWTH IN CHILDREN[1]

WILTON MARION KROGMAN[2]

Eddington once calculated that if a million and a half people talked continuously for a year enough energy would be created to boil one cup of tea. It is not mere talk we want, therefore, except that discussion be ever the prelude to action. It is in this spirit that I offer the following observations on current trends in the study of the physical growth of the child - a sort of stock-taking, as it were.

The first trend is that of standardization. There have been innumerable osteometric and somatometric studies embracing the bones of the dead and the bodies of the living, ranging from foetus through the senile. We have amassed mountainous piles of dimensions, measurements, indices, formulae, constants, variables, so that of the peoples of the Earth, of the ages of Man, we know race differentiations and racial and individual growth curves. Yet, if we examine this overwhelming bulk of material with the exacting rule of precise comparability we are apalled, as pointed out by Mahalanobis, to find that 80 per cent of it is so much waste effort, only 20 per cent scientifically accurate, methodically comparable. We may offer as an excuse that anthropometry is a relatively new science, that trial and error are the rule of early days of learning, but we cannot accept such evasion any longer. When one notes that leg length may be measured by any one of nine different methods, sitting height by any one of three; that in measuring arm length there are no less than eight postural variants which may defeat accuracy - then, I say, the time has come to look for precise definition of end-point, accurate statement of derived measurement, standardization of instrument, and uniform training of technician. We must never forget that care and experience are inseparable; the two can never be divorced. For some years I have been a member of the International Committee for the Standardization of Anthropometric Technique, working in harmony with the Committee on Anthropometric Interests of the American Association of Physical Anthropologists. We are working on the problems of precision and uniformity; we are assessing end-points and measurements in terms of inherent variability; we are weighing dimensions and indices in terms of import. In short anthropometry is being refined: the mineral shall be kept, the dross discarded.

The second trend is based upon the interpretation of anthropometry from a biological viewpoint. We are, first of all, measuring Homo; there are sizes and proportions that must be basic to Man as an orthograde Mammal, and as a higher Primate; within these relatively fixed physical constants there will be a variability related to sex and to stock or race. We come, therefore, to a classification of measurements proposed and developed at Reserve in the study of male and female American Whites and Negroes.

1) Humanity-linked, uninfluenced by stock or sex. These are umbilical height; length and breadth of hand proportionate to arm; length and

[1]Revised version of paper read before Child Development Committee of the University of Chicago.

[2]Associate Professor of Anatomy and Physical Anthropology, University of Chicago.

breadth of foot proportionate to leg (except in female White); upper face height with minimum frontal diameter and bizygomatic breadth; site of acromiale (except in female Negro).

2) Sex-linked, uninfluenced by stock. These are bi-nipple breadth; vertical dimensions of the pelvis; high heel (in male White); arm-span; transverse chest diameter; relatively short limbs and feet (in female White); relatively short limbs but not feet (in female Negro); head length and circumference, auricular height all relatively small in females.

3) Stock-linked, constant for both sexes of a given stock. These are nipple height relatively greater in Negro; transverse breadth of false pelvis less in Negro; vertical height of pelvis relatively less in Negro; external conjugate greater in Negro; sagittal diameter of chest less in Negro; long limbs are Negroid, especially a relatively long forearm, though not necessarily leg (shin); nasion-nasospinale is less in Negro, nasospinale-prosthion is more; nasal breadth and depth, lip thickness, and interpupillary distance are greater in Negro.

What, you may well ask, does all this have to do with growth? The answer may be given in the form of a paraphrased proverb: "As the tree is inclined so must the twig have been bent." It is probably correct, at this stage of our rather imperfect knowledge of racial growth, to conclude that in achieving an ultimate adult pattern a specific sequence and rate must have been followed. In statural growth, time remaining constant, velocity must be greater in a taller stock, less in a shorter; similarly, bicristal diameter must increase more rapidly in a shorter, heavier stock. So-called racial types of growth remain to be explored; that they exist there can be little doubt. They must be recognized as definite strands in the warp and woof of the growth pattern.

Now, what about the measurements themselves? Are they all of equal reliability, do they all tell their story of growth with equal truth? I cannot answer these questions save by illustrating with the analysis of several of the more routine measurements of growth.

1. Weight
2. Height, vertical and recumbent
3. Sitting height
4. Acromial height (left)
5. Suprasternal height
6. Biacromial breadth
7. Transverse chest diameter
8. Bicristal breadth
9. Chest circumference
10. Entire arm length
11. Hand length
12. Trochanteric height
13. Tibial height
14. Head length
15. Head breadth
16. Head height

Here are certain measurements of body linearity and breadth, of limb linearity, and of cephalic size. Measurements 1, 2, and 6 give increase in dimensions and of general body size, while the difference between vertical and recumbent height is a measure of posture and muscle tone; 10, 11, 12 and 13 are of use in the analysis of limb size and proportion; 5, 7, and 9 are apt to be influenced by respiratory nervousness - they tell as much of emotional stability as they do of trunk growth; 8, if repeated serially, will give an idea of the sex-growth-pattern; 14, 15 and 16 are of use only up to about six years of age; 3 and 4 are so variable, affected by postural adjustments, as to be of limited value.

Thus we see that the measurements themselves, no matter how precise

their definition, how exact their delineation, vary with reference to diagnostic import.

There is another aspect of anthropometry to be noted, namely, the unevenness of incremental growth. Time has no constant value in growth and development; there are "spring-up" and "fill-out" periods; there are spurts of rapid growth, phases of slow progress. But the major theme is one of integration so that spring-up and fill-out, spurt and slow phase, alternate rhythmically to produce balance and at least an attempt towards attainment of an optimum. It is to be remembered that perfection may be the standard, but adequacy is the goal.

I touch upon one more phase of anthropometry and then I go on. We speak quite freely of posture by which we hope to study poise, whereas we actually study pose. Posture is the alignment of the skeleton and muscles of the body in any particular positional pattern. Poise is the delicacy of balance in movement or position. Pose is the self-conscious and even awkward attitude assumed individually under emotional stress, whether from being under observation or in strange surroundings. It must be the aim of the anthropometrist to eliminate pose as a variable factor in the study of the growing child. This can be achieved only if measurer and subject are in absolute rapport.

The third trend is that of the study of the hereditary transmission of physical characters. In a sense the consideration of family-, sex-, and stock-linked characters has already touched upon this theme, for physical traits common to man as Man, man as a bi-sexed organism, man as a racial entity, are transmitted in accordance with biological laws. I would focus attention now upon family-line growth patterns, a theme enunciated by Boas over thirty years ago, but not until recently elaborated.

The recognition of heredity as a broad stream of biologic impulse manifesting itself in generational succession is in itself the best indication of variability. The formative influences in our genetic make-up allow a latitude compatible with the paternal-maternal complex. We still do not know the exact modus operandi of transmission in terms of dominance and recessiveness, but Jennings has shown that what one inherits is certain material that under certain conditions will produce a particular character. The "certain conditions" is the variable here; we strive to hold conditions at a constant and beneficial high level in the hope that the result will be a well-born child. Pearl has shown, however, that on the basis of animal breeding the only reliable test of genetic superiority is the progeny test, the test of the quality of the offspring actually produced. It will be some generations before we can apply this test to Man!

It is quite likely that bodily growth is controlled by at least two sets of genetic factors, the first governing general dimensional growth, the second purely linear or purely circumferential dimensions. Individual differences in pattern - either growth or body-type - are due to the interaction of factors of general size and factors of proportion in the several bodily parts. There is some evidence that the general size factors are the more variable.

Meanwhile we focus attention upon the variants of the "certain condition" mentioned by Jennings. These are the environment in the widest possible sense. To turn to this theme is beyond the scope of this

discussion. We can but cite the nutrition studies of Jackson, the nutrition-illness studies of Bakwin and Bakwin, the generational studies of Boas, the depression studies of Palmer, as proof that the food environment, the socio-economic milieu, the socio-cultural background all register themselves physiologically in skeleton, muscle and tissues. Here is a field of growth studies as yet unexplored, but infinite in its ramifications and of great promise. We must learn family-line type, family economic circumstances, family health history, family social balance and adjustment - in short, the growth of the child is a reflection of his biologico-cultural inheritance immediately through his familial environment, ultimately through his morphologic make-up.

A fourth trend in the study of physical growth is to depend somewhat less upon dimensions and a bit more upon maturation. The assessment of physical maturity via the X-ray is an important feature in the analysis of the "growing-up" process, and is an excellent check on chronological age and physical growth as measured in incremental increase. But even in the maturational theme there are gradations; the order of appearance of centers in infancy depends in part on vitamin elements (especially D) in the diet; this is not so true of the union of centers in adolescence; the progress of ossification in the grade school period is dependent for detail upon health vicissitudes. There are asymmetries in maturation no less than asymmetries in dimensional increase, but the two are not basically related; maturation runs concurrent more with visceral growth, less with size-changes in bodily frame. Changes may occur in bone-ends with no registration of progress in height and weight. Progressive stages of maturation have no direct tie-up with growth, but are a measure of metabolic integration. Discrepancies in maturation bespeak functional inadequacy; discrepancies in dimensions bespeak a more transitory and less deep-seated imbalance.

In the new-born child organs and blood form 35 per cent of body weight, "stores" of growth 65 per cent; of these stores bones form 10 per cent, muscle 20 per cent, fat 35 per cent. In the adult organs and blood are 20 per cent, stored material 80 per cent; of the latter bones form 20 per cent, muscle 40 per cent, fat 20 per cent. The bones are the framework and a storehouse for lime; the muscles give power of movement and store carbohydrates and protein; subcuteneous fat is a non-conductor of heat and a store for the steady drain of energy demanded by growth. Now when we measure stature we get an idea of bone growth but not of developmental growth; when we measure weight we include bone and do not differentiate muscle and fat; the height-weight ratio is an attempt to express proportions of bone, muscle and fat. But these are all estimates of growth, and do not afford a qualitative estimate of maturational progress or well-being. We turn, therefore, to the study of tissues as seen in the X-ray, a study elaborated by Dr. Todd and only in part prepared for publication at the time of his death. It is qualitative and, at the present stage, relatively subjective, but it holds promise of at least partial standardization.

Muscle tone and the composition of subcutaneous tissue have been estimated by clinical assessments of "turgor," and by quantitative measurements, either directly or indicial, as, for example, the ACH index. A lateral X-ray of the hand of a child will demonstrate the density of

muscular tissue very well. Children with "light" muscle shadows fatigue easily, they are prone, likewise, to mental fatigue, with overt symptoms of restlessness, impatience, and irritability; there is apt, in this type, to be a difference of 25 mm. or more between vertical and horizontal height. They demonstrate clearly that often poor posture is due less to habit than to constitutional debility.

Subcutaneous tissue, studied best in an X-ray of the elbow, should show clearly in the X-ray. Density of shadow is an indication of a water-logged and edematous condition, probably due to defective fluid metabolism, particularly manifested in gastro-intestinal allergies.

The skin is thin in infancy, a trifle thicker in later childhood, moderately thick in healthy young adult life, and progressively thinner in middle- and old-age. There should be clear-cut delineation in the X-ray, with perfect definition from subcutaneous tissue, and freedom from edematous folds or wrinkles, seen especially at the wrist.

A fifth trend, and one which I mention with a considerable amount of trepidation, is a closer tie-up between physical growth and mental progress. As late as 1930 Paterson concluded that physiological development and complicated morphological indices of body build were relatively unrelated to mental development. Shortly thereafter, in 1933 and again in 1936, Jones pointed out that any one measure of physical size, with age held constant, and any one measure of mental status were correlated too low (below +.30 and usually +.10 to +.20) to predict one from the other. In 1937 Olson, however, demonstrated that if chronological, dental and carpal ages (the latter two estimates of maturity) be equated with derived test-score ages (mental age, reading age) and dimensional ages (height age, weight age) the curves of progress are comparatively uniform. Within bounds the organism as a whole shows a definite and therefore predictable interrelationship between physical, mental, social and emotional development.

We have, in the past, been comparing two aspects of development - physical and mental - on the basis of yardsticks not comparable, yardsticks calibrated to units of a year, a unit of sidereal and not of biologic time. We must differentiate between trend and phase, must recognize that comparable points may be far apart on the scale of time, and must envisage progress rather than status.

Let me make graphic the points just listed. The body achieves its full dimensional development at about twenty years, and shortly thereafter the adult functional state is reached. The brain achieves its full dimensional growth in six years or less, and from then on time and experience, via training, must develop capacity into ability. Brain is far more dependent than body function upon adjustments to, and acceptance by, the environment. Not only are the time-scales of body and brain growth not comparable, but the very growth processes themselves cannot be equated: body growth is biologic, brain growth and brain expansion (mental development) biological and culturo-social.

I turn, finally, to a sixth trend, namely, the utilization of growth data as the basis of the assessment of well-being. We have long focussed upon the group, and the position of the individual growth curve in the group, and have constructed averages - "norms of mediocrity," Todd called them - degree of departure from which was a measure of aberrancy. We now

look more intently at the individual growth curve as an expression of its own norm. A uniform trend, an even progress to maturity, is the best guarantee that healthy growth is present. A child whose bone mineral, as seen in the X-ray, is deficient, whose muscle shadows are light, whose connective tissues are dense, whose stature increments are poor, whose weight gain is erratic, whose mental alertness is stultified, whose emotional poise is unstable - that child is a sick child, clinical symptoms whether or no!

I terminate these observations with a quotation from C. E. Montague:

> "It is essential to graft upon the bodily sense of sight a special kind of imaginative energy, so that when the fit eye has gone as far as it can, its work is taken over and carried on without a break, so that, when later you try to remember, you cannot say where physical perception stopped and where mental vision began - all you know is that between them they have left you the memory of expanses greater than bodily eye ever say, and also more urgently real than imagination alone could ever frame . . . ."

The study of child development needs just such vision, for we must ever remember that faith is the substance, not the shadow, of things hoped for.

THE CORRELATION OF LANGUAGE ATTITUDES OF DELINQUENT BOYS TO THEIR PREVIOUS INSTITUTIONAL BEHAVIOR

WILLIAM FAUQUIER[1]

Individuals' attitudes are intimately related to definite values which they have established in their struggles to gain and protect feelings of prestige and security. Consequently, attitudes always involve problems of relationship between a person and his environment and may be thought of as being preparatory reactions for actual behavior.

The complex nature and genesis of most attitudes and their continuous change under the influences of daily life make their systematic detection in the clinical situation very difficult. When discovered, however, they indicate the direction and extent of personal difficulty because, as Sherman has pointed out, many attitudes develop as a result of problems and conflicts (10). The determination of attitudinal patterns is, therefore, ipso facto, one of the major problems in the differential diagnosis of children's problems.

In clinical practice a person's attitudes are considered with reference to his background. Theoretically, if the examiner is familiar with the home, school, neighborhood, and special environments of the behavior-problem child and discovers how that child feels about multiple aspects of these environments, he is able to detect the causative factors in the disorder and to substitute treatment which will alleviate the tensions or assist in adjustment to them. Such a diagnostic foundation presupposes, among other things, two factors: first, a reliably accurate and comprehensive sampling of attitudes toward crucial situations; second, the interpretation of these attitudes according to the tenets of some psychological system so as logically to explain the behavior.

With the second factor, interpretation, this study has no dealings, the investigation being limited to a discussion of the factual reliability of verbally expressed attitudes particularly as this pertains to attitudes toward social situations where the subject is able to surmise the desirable and socially approved points-of-view.

The average delinquent boy facing the examiner for the first time is usually conscious of what brought him there, desirous of creating a favorable impression, and frequently comes fortified with a good understanding of right and wrong especially as he must make moral and ethical distinctions in regard to his own activities and inclinations.

Beside being partially unaware of many of his basic attitudes, a boy will commonly evade, distort, exaggerate, minimize, and endeavor to focus attention upon unimportant matters. Hartshorne and May have pointed out that lying and cheating are closely related to classroom association, emotional instability, poor resistance to suggestion, and cultural and social limitations in the home background. "Where conflict arises between a child and his environment, deception is a natural mode of adjustment . . . The motives for cheating, lying, and stealing are complex and inhere for the most part in the general situations themselves. The

[1] *This is the third in a related series of studies conducted at Berkshire Industrial Farm, Canaan, New York.*

CHILD DEVELOPMENT, Vol. 11, No. 4 (December 1940)

most common motive for cheating on classroom exercises is the desire to do well." (7,412)

For these reasons many of the verbal attitudes expressed by problem children represent merely the level of their social understanding, intellectual acuity, or the dubious results of deliberate or unconscious attempts at deception and fail frequently to reveal the important affective elements which strongly influence his overt responses in frustrating circumstances.

As this study subsequently demonstrates, a high percentage of the language attitudes expressed by delinquent boys do not seem to constitute, without extensive observational opportunities, a sound basis upon which to interpret accurately the specific causes of past behavior or to make reliable prognostications in regard to future conduct. In the normal distribution of children's problems, those cases lying at either extreme of the adjusted-mal adjusted continuum present relatively simple problems in diagnosis. But for each one of these the clinical worker is confronted by a very large number in which attitudes and conduct are not extreme in any sense of the word. These represent the most refractory cases in that their later adjustments frequently show these boys to behave in a very different manner from what one had been led to predict from original examination. This discrepancy between prognostic assumptions and later adjustment is easily explainable if we consider the large disagreement between verbally indicated attitudes and actual inherent behavior potentials.

This paper reports briefly an investigation of the correlation between language attitudes of delinquent boys and their previous related institutional behavior. Although the subjects represent a sampling from a single population, the problems and backgrounds of these individuals are typical of delinquents elsewhere.

METHOD

As a part of the routine record keeping on Berkshire Industrial Farm, a daily report of the boys' misconduct is tabulated at the end of each year. This affords valuable comparative criteria for the measurement of group and individual adjustment. In two earlier studies (5, 6) this procedure has been described. For clarity the record form used in this type of recording is shown in Table 1.

The conduct record of the subjects in this study extends over a period of twelve months antecedent to examination. With knowledge of the type and extent of each individual's overt misconduct during the previous year, a questionnaire was devised to sample the boys' attitudes toward a variety of social situations similar or identical to incidents in which they were reported for socially unacceptable behavior.

The questionnaire entitled, "What Would You Do?" consisted of thirty behavior-situations, ten in each of the three principal categories of the record form in Table 1. To most of the behavior-situations five objective replies were offered, and the boys were asked to check the responses which best represented their points-of-view. Especial care was taken to reduce socially favorable bias by wording the behavior-situations in such a way as to voice antagonistic viewpoints. By this method the possibility of eliciting truthful responses from boys who would ordinarily react

TABLE 1

FORM USED IN THE RECORDING OF REPORTS FOR MISCONDUCT

Name . . . . . Admitted . . . . . Born . . . . .

		Conduct Reports by Months											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
AVOIDANCE OF RESPONSIBILITY	breach of routine												
	shirking work or duty												
	missing appointments												
	inattention												
ANTI-SOCIAL BEHAVIOR	stealing												
	lying												
	violence, cruelty												
	destruction of property												
	disobedience to gain end												
INFANTILE BEHAVIOR	runaway												
	temper												
	negative-spite reactions												
	attention getting												
	insolence												
	swearing												
	TOTAL												

in an aggressive and antisocial manner was considerably reinforced. For comparative purposes the responses were weighted according to the maturity of the reply. A high total score represented infantile or antisocial tendencies and a low score being commensurate with good social adjustment. The following examples which include the weights assigned to each response are typical of the thirty behavior-situations.

Clothes and towels and toys must be kept in their places to keep the house tidy. No one is harmed, however, if once in awhile you forget to put your belongings where they belong. Therefore, if you are punished for such a small thing as leaving your shoes in the parlor, you feel that this is ___ (check one)

- unfair because it is such a small thing. (wt. 2)
- right because boys should never do anything wrong. (fooler)
- wrong because your mother or guardian should pick it up. (wt. 3)
- right because small things are as important as large. (wt. 1)
- wrong because you have committed no crime. (wt. 3)

All of us want to win success, many things come up to prevent us. We must work and fight to get what we want. Sometimes we are not given what we earn or are cheated. Below are some sayings about getting along in life. Put a (1) in front of the saying you like best and a (2) in front of the saying you like next best. Write only two numbers to show your first and second choice.

- I trust everyone always. (fooler)
- I smash my opponents by fair means or foul. (wt. 4)

- I oppose the wishes of no man. (wt. 3)
- I live up to all rules even if no one else does. (wt. 2)
- I will cheat if I am cheated. (wt. 4)
- I live and let live. (wt. 1)
- I will take the law into my own hands if necessary. (wt. 3)
- A successful man must be hard and selfish. (wt. 5)

Suppose you are in a hurry to go out. You are told that all your sweeping must be done over because there are a few specks of dust on the floor. This seems unreasonable to you. You feel like --

- telling the person to clean it up herself if she doesn't like it. (wt.3)
- arguing about it because it is unfair. (wt. 2)
- swearing under your breath but doing what you are told. (wt. 1)
- laughing and cheerfully doing it because you always mind. (fooler)
- running away because of this unfair treatment. (wt. 4)

The second example is atypical in that eight instead of five responses are offered. The weights assigned to the replies were in all cases conservative. The original plan of weighting from one to five was discarded in many instances when differences were slight or non-essential. In almost every question a "fooler" response was included to measure the presence of self-righteousness or what is often termed the "halo effect."

VALIDITY OF THE QUESTIONNAIRE

Before correlation of the scores with the number of reports for misconduct was made, the questionnaire was tested to determine whether it had been satisfactorily differential in its measurement; that is, whether it showed significant quantitative differences between the scores of delinquents and those of normally adjusted individuals. For control purposes it was administered to a group of subjects from a New York public junior high school who were making satisfactory adjustments to their home, community, and school environments.[2] Table 2 presents the important characteristics of the two groups.

TABLE 2

MEAN I.Q., CHRONOLOGICAL AGE, GRADE, AND MEAN NUMBER OF REPORTS FOR MISCONDUCT; AND NUMBER OF BOYS IN EACH GROUP

Group	Median I.Q.	Median Age	Median Grade	Mean Number of Reports for Misconduct*	No. of Boys in group
Delinquents	93	14-9	7.2	26.75 ± 1.76	73
Normal-Control	90	15-4	8.7	- -	40

*For the normal control group no conduct record was available.

For more critical purposes the delinquent boys were subdivided according to position above or below the mean number of reports for misconduct for the whole group. Two delinquent groups were formed (1) institutional-aggressive boys with a high misconduct count; (2) institu-

[2]*The Chatham Central School, Chatham, New York.*

tional-submissive boys with a low misconduct count. For purposes of meaningful correlation the questionnaire should show a reliable difference between the mean scores of (a) the delinquent and normal groups; (b) between the aggressive and submissive delinquent groups; (c) between each of the delinquent groups considered separately and the normal group.

For the convenience of recording, the institutional group[3] will be represented by the symbols I-G; the institutional-aggressive group by I-A; the institutional-submissive by I-S; and the normal control group by N-C.

TABLE 3

MEAN SCORES OF VARIOUS GROUPS ON THE ATTITUDE QUESTIONNAIRE

Group	Mean Questionnaire Score	Maturity Ranking
N-C	44.80 ± 0.57	Highest Maturity
I-S	50.81 ± 1.20	Median High Maturity
I-G	54.05 ± 1.29	Median Low Maturity
I-A	62.60 ± 2.45	Lowest Maturity

TABLE 4

PROBABLE ERRORS OF THE DIFFERENCES BETWEEN THE MEANS OF THE QUESTIONNAIRE SCORES FOR THE VARIOUS GROUPS

Group	Probable Error of the Differences Between the Means		
	I-G	I-A	I-S
N-C	6.76	7.1	4.55
I-G		3.1	1.84
I-A			4.45
I-S			

The probable errors of the differences between the means satisfies the standards previously mentioned.

To further demonstrate the effectiveness of the questionnaire, the delinquent boys were subdivided according to their positions above or below the mean maturity score on the questionnaire for the whole delinquent group (54.05) and the mean number of reports for misconduct for these two groups computed. By this procedure an arbitrary misconduct count was obtained for the delinquent boys classified according to their maturity as estimated by the questionnaire score. In Table 5 the high-maturity group is represented by those boys whose score was below the mean for the total delinquent group, and the low-maturity group by boys whose score was above the mean score.

The probable error of the difference between the mean number of misconduct reports for the high-maturity and the mean number for the low-maturity groups is 8.1.[4] This corroborates the data of the previous tables, namely, that for groups a high record of misconduct and a low social maturity are closely related. If the normal control boys were

[3] *Institutional group: total delinquent group undivided.*

[4] *A difference or a statistical constant of any sort is not significant unless it is at least four times its probable error.*

TABLE 5

MEAN NUMBER OF REPORTS FOR MISCONDUCT RECEIVED BY THE HIGH-MATURITY AND LOW-MATURITY GROUPS OF DELINQUENTS*

Group	Number of Reports for Misconduct During Twelve Previous Months	Questionnaire Score
High Maturity Group	19.47 ± 1.03	Below 54.05**
Low Maturity Group	36.82 ± 3.75	Above 54.05

*The mean number of misconduct reports for previous twelve months for the whole delinquent group is 26.75

**See Table 3 for this figure.

similarly subdivided on the basis of the questionnaire scores, it is likely that the boys would fall roughly into two groups - one characterized by mature and tractable conduct and the other by relatively immature and unsocial behavior.

TABLE 6

MEDIAN NUMBER AND RANGE OF "FOOLER" RESPONSES MARKED BY THE BOYS IN THE THREE GROUPS

Group	Median Number of "Fooler" Responses Marked	Range of "Fooler" Responses Marked
N-C	4.25	0 - 16
I-S	4.17	0 - 20
I-A	0.84	0 - 4

The institutional-aggressive boys showed either more sophistication in their choice of responses in that they refused to mark the "fooler" statements or they were more truthful in following the dictates of stronger antisocial feelings. Conversely, the normal control and institutional-submissive boys appear to be more suggestible to favorable social bias or they possess actually a higher degree of socialization. If the behavior record is a reliable reflection of inherent attitudes, probably the latter is true in each case.

CORRELATION OF ATTITUDES TO INSTITUTIONAL BEHAVIOR

The linear correlation between the questionnaire scores of the delinquent boys and their records of misconduct for twelve months previous to examination was 0.55 ± .058, many boys with a high misconduct record receiving a low questionnaire score (high maturity indication) and many well adjusted tractable individuals showing a high score (low maturity indication) on the questionnaire.

This discrepancy between verbally expressed attitudes and actual behavior suggests that, even with perfect cooperation from the subject, language attitudes frequently are not reliable indicators of behavior tendencies or potentials. Regardless of the perception of right and wrong, and often despite an honest intention of behaving in a socially sanctioned manner, problem children habitually react in ways which have become strongly fixed due to the motivation of affective forces generated

and maintained by tensions and conflicts within themselves or between them and factors in their environments.

There is an urgent need for clinicians to develop and to utilize a more objective diagnostic instrument, such as perhaps the photopolygraph, not only to supplement the impressionistic interview but for the critical examination of many phychological and psychiatric concepts still in popular use although frequently based on questionable scientific notions.

BIBLIOGRAPHY

(1) Adler, Alfred: Understanding human nature. New York, Garden City Publishing Company, 1929.

(2) Blos, Peter: Aggression in children. Child Study, (May) 1928, 228-230, 252.

(3) Baker, H. J. and Traphagen, V.: The diagnosis and treatment of behavior-problem children. New York, The Macmillan Company, 1936.

(4) Dollard, John, and others: Frustration and aggression. Yale University, The Institute for Human Relations, 1938.

(5) Fauquier, William: The measurement of attitudes of delinquent and normal boys by use of an associational technique. Child Development, 1939, 12, 231-239.

(6) Fauquier, William: The attitudes of aggressive and submissive boys toward athletics. Child Development, 1940, 6, 115-125.

(7) Hartshorne, Hugh and May, Mark A.: Studies in the nature of character. New York, The Macmillan Company, 1930.

(8) Sherman, Mandel: The development of attitudes. Baltimore, The Payne Fund, Waverly Press, Inc., 1933.

(9) Sherman, Mandel: Mental hygiene and education. New York, Longmans, Green and Company, 1936.

(10) Sherman, Mandel: Mental conflicts and personality. New York, Longmans, Green and Company, Inc. 1938.

TESTS OF MOTOR EDUCABILITY FOR THE FIRST THREE GRADES

AILEEN CARPENTER[1]

In the preschool and kindergarten much of the time is spent in supervised and directed activity, both education through the physical and education of the physical, but when the youngster reaches the first grade most of this is over and he finds himself in quite a different situation. Wellman (6) claims to have shown that preschool education, much of it similar to a good program of physical education, raised the I.Q.'s of the children an average of 8.2 points, which gain lasted through the grades, high school, and college. Not too much is known about what specific activities stimulate the educational development of the child, but it is probable that the responses to the physical educational activities contribute their full share. What then should the teacher of physical education be doing for these first, second and third graders in order to accomplish the most possible in the little time now allowed for such activities? We talk about rhythmic activities, about stunts, about ball handling, and about games, but how well are the relevant fundamental skills taught? And how much is known about the capacities and abilities of the individual youngsters for learning such skills?

McGraw (4) in her studies of identical twins demonstrated remarkable results with the experimental twin, Johnny. He learned an amazing number of skills at an early age. He swam across a swimming pool under water when only ten months old, dived when thirteen months old, and roller skated at sixteen months - apparently only because he was encouraged to respond in situations which were well set. We do not necessarily want all of our Johnnies diving at thirteen months but this does make us wonder a bit how much we may be holding some of these youngsters back by our own inabilities - inability to understand their capacities as much as inability to arrange such stimulating situations.

The achievements of Johnny and the alleged increased I.Q.'s of the preschoolers stimulate in some of us a strong suspicion that a better physical education would not only be good for these youngsters physically but might also go a long ways toward furthering the development of intelligence and general command of the social processes. So why be content with what we have, especially in those lower grades?

We need experimentation in how to do a better job with these children. Experimentation implies measurement. So the tests described in this paper are suggested for a double purpose. Through their use we are able to find out a little more about each student; which is poor in this phase of educability, which needs special work administered with more patience, and which could readily learn more than we are presenting. We have not usually divided the lower grades into squads. Who knows whether or not it would be desirable until we have some valid objective means of making the division? These tests are suggested for such uses.

Still another use of these tests will be as a basis for further research at this grade level. The first, second, and third graders are like the forgotten man! There is much flurry over preschool and kinder-

[1] *From Teachers College of Kansas City, Kansas City, Missouri.*

garten education, but almost nothing more is heard of research in the child's physical education until he comes forth into the Motor Quotient, Classification Index and P.F.I. area beginning at about the fourth grade.

The five tests recommended in this paper were taken from a battery of twelve Johnson (1) type tests. Johnson proposed his test for the purpose of sectioning classes into homogeneous units. Later it was shown (2) to be an especially good test of motor educability, the readiness with which an individual learns a new motor skill. If classes are divided according to records made in such a test, those of the high group can be expected to accomplish much more in less time than those in the lower groups. Since many of the test items in the original Johnson battery are far too difficult for children of this age, the author devised a series of nine tests using a modified Johnson mat and added to these the original Johnson tests numbers 1, 2 and 3. For the children of the ages tested it was found that the Johnson mat squares were too large. After considerable experimentation the dimensions of the mats were reduced one-third. Records of these tests were obtained on 128 boys and 125 girls of the first, second, and third grades. Reliabilities were computed for each test. These will be found in Table 1. Tests, C, J, K, and L were found to have reliabilities too low to justify further study

TABLE 1

JOHNSON TYPE TEST RELIABILITIES

A	.7977	G	.8471
B	.7675	H	.8976
C	.6140	I	.6966
D	.7175	J	.6422
E	.8106	K	.4782
F	.8217	L	.5972

so these were eliminated. Each of the remaining eight, with the Johnson total (the combined scores of the eight), right and left grips, and three small muscle coordination tests[2] were intercorrelated and a factor analysis according to Thurstone's method (5), with rotations done two at a time, was carried out. The grips and small muscle coordination tests are not used in this battery of tests of motor educability. They were included in the study for two purposes. First, an additional study has been made of those tests; second, those tests enabled the author to orient the strength and small muscle coordination factor axes in the factor analysis. This enabled us to be much more sure of the identification of the educability factor as such, and to be able to choose the educability tests that were least complicated by strength and small muscle coordination.

Table 2 gives the intercorrelations on which the factor analysis was based. Table 3 gives the resulting rotated factor loadings.

[2] *"Bells" Two desk bells are placed one foot apart so that the child makes movements from side to side in striking first one, then the other bell. Score is number of times bells are struck in ten seconds.*

"Marbles". An open box containing marbles is placed next to a closed box which has a hole one inch in diameter cut in the lid. Score is the number of marbles that the child picks out of the open box and puts through the hole in the second box, one at a time, in thirty seconds.

"Ball bounce". The score is the number of times up to fifty that the child consecutively bounces a rubber playground ball without stepping out of a space one foot square.

TABLE 2

INTERCORRELATIONS ON WHICH THE FIRST TWO FACTOR ANALYSES ARE BASED

	Left grip 2	A 3	B 4	D 5	E 6	F 7	G 8	H 9	I 10	TJ 11	Marbles 12	Bells 13	Ball bounce 14
BOYS													
R. grip	.7183	.2704	.2452	.1832	.1696	.2053	.1999	.2984	.3035	.3275	.2312	.2719	.3579
L. grip		.2105	.2505	.2353	.1771	.1709	.1697	.2293	.2756	.2967	.1877	.2125	.2745
A			.7265	.5526	.4555	.3965	.3358	.4094	.4613	.7383	.2586	.4466	.3461
B				.4464	.4578	.5229	.3616	.3789	.4000	.7158	.2112	.1512	.2848
D					.4148	.4238	.6851	.4491	.4230	.7453	.1171	.2946	.3163
E						.4892	.4863	.4496	.4082	.6800	.2524	.2725	.3195
F							.4096	.5184	.5732	.6894	.2551	.2477	.3717
G								.4451	.4480	.5773	.1116	.1792	.2509
H									.7660	.7406	.2095	.2522	.4571
I										.7088	.1753	.2355	.4219
TJ											.2684	.1900	.4470
Marbles												.5218	.2066
Bells													.2433
GIRLS													
R. grip	.6776	.1727	.1625	.0162	.2758	.2459	.0581	.1972	.1680	.2264	.2711	.1123	.2436
L. grip		.1045	.3789	.0274	.1936	.2777	.1433	.1420	.1621	.2173	.1478	.1836	-.0221
A			.7691	.4294	.5018	.3830	.4568	.2554	.3934	.6120	.4055	.4918	.5829
B				.4611	.3966	.3814	.3745	.2861	.4038	.7058	.3970	.3427	.6315
D					.3725	.3237	.5372	.2939	.3616	.6285	.2806	.2414	.3352
E						.6041	.2867	.3196	.5455	.7067	.3744	.3130	.4513
F							.2618	.3482	.4803	.6699	.3444	.2426	.3417
G								.5133	.3714	.6488	.3668	.2260	.5152
H									.7148	.8236	.3551	.1117	.2256
I										.8236	.3614	.1442	.3226
TJ											.4983	.3222	.3361
Marbles												.4780	.1033
Bells													.4277

TABLE 3

ROTATED FACTOR LOADINGS FROM THE FIRST TWO FACTOR ANALYSES

	I	II	III	I	II	III
	BOYS			GIRLS		
R. grip	.7456	.0312	-.0385	.7036	.0041	.0369
L. grip	.6844	.0041	.0036	.6958	.0067	-.0227
A	.2989	.6088	.4204	.2812	.5203	.6342
B	.2239	.6533	.2687	.3135	.5068	.5719
D	.2445	.7032	.0655	-.0241	.6298	.2095
E	.2827	.5881	.1814	.3023	.6180	.1395
F	.3036	.6173	.1207	.4227	.5385	-.0083
G	.2331	.6526	-.0701	.0605	.6329	.2196
H	.4234	.6231	-.1431	.2504	.6977	-.2308
I	.4185	.6410	-.1769	.3345	.7400	-.1840
Total Johnson	.3621	.8902	.1002	.2655	.9949	-.0073
Marbles	.3597	.0676	.5180	.2882	.4321	.2429
Bells	.3544	.1322	.5066	.2857	.2283	.5528
Ball Bounce	.5293	.2408	.2604	.2219	.4406	.4617

In both analyses the Johnson type tests stand apart from the other tests analyzed. Obviously they represent a different factor, one which appears to be a type of motor educability.

A series of partial correlations was then computed. In the computation of these partials the factor loadings with the educability factor were used as zero order correlations between the test and the factor, and the intercorrelations between the variables were used for the other correlation coefficients necessary to the partial correlation formula. As a result of these partials, it was decided that, for boys, test A could be safely dropped because it makes the same type of contribution as B but does not do it as well. With the girls B was dropped because of its duplication by A. It would also seem from the partials that H could be discarded from the boys and F from the girls. The other partials did not seem to us to justify dropping any of the other tests, so multiple correlations were computed with various combinations of the remaining tests. Table 4 gives the multiples for boys, Table 5 gives those for girls.

TABLE 4

MULTIPLE CORRELATIONS WITH THE EDUCABILITY FACTOR - BOYS

R	O.BDEIH	.8732	R	O.EDI	.8308
R	O.BEFGDI	.8727	R	O.BEFG	.8265
R	O.BGDIE	.8683	R	O.BDE	.8264
R	O.BDEI	.8537	R	O.BGD	.8010
R	O.BGDI	.8597	R	O.BD	.7990
R	O.BEFGD	.8528	R	O.BG	.7654
R	O.BDI	.8501	R	O.BEF	.7648
R	O.EDIG	.8361	R	O.BE	.7279
R	O.EDHI	.8334			

TABLE 5

MULTIPLE CORRELATIONS WITH THE EDUCABILITY FACTOR - GIRLS

R	O.AEGDHI	.9006	R	O.EDI	.8535
R	O.BDGHI	.8997	R	O.BDEI	.8514
R	O.EDHIB	.8894	R	O.EDG	.8127
R	O.AEGDH	.8887	R	O.AEGD	.8134
R	O.EDHI	.8884	R	O.AEG	.7829
R	O.EDGI	.8842	R	O.ED	.7533
R	O.EDH	.8781	R	O.AE	.6641

For boys the combination of four giving the best multiple correlation was B D E I with an R of .864, for girls E D H I with an R of .888. Three of the tests included are identical so B was added to the girls' battery with a resulting R of .889 and H was added to the boys' battery with a resulting R of .872. In both cases the R's are better than those resulting from other combinations of five. Consequently it was decided to use these five tests in a battery for the measurement of this type of motor educability for boys and girls, since in most elementary school situations both sexes are tested together.

From multiple regression equations for each sex the following weightings were computed:

Boys: 1.0458 B + 1.8329 D + .6569 E + 1.0499 I + .7184 H

This was simplified to 1 B + 2 D + 1 E + 1 I + 1 H

Girls: .9887 E + 2.0184 D + 1.6349 H + 1.0245 I + .2363 B
This was simplified to: 1 E + 2 D + 1.75 H + 1 I + .25 B

The five tests were combined both unweighted and weighted for each individual and were intercorrelated with their components, the grips, weight, and a group of speed and coordination tests.[3] All seventeen were then put into factor analyses, boys and girls separately, and the work was done according to Thurstone's method with rotations two at a time. Table 6 gives the resulting rotated factor loadings.

Apparently the Johnsons unweighted and those weighted are of practically the same value in the prediction of this type of educability. A comparison is given in Table 7.

The differences are so small that it was decided to use the five unweighted. This seems especially advisable considering the volume of work eliminated. If classroom teachers are expected to use these tests - and they are - they will be much more likely to do so if the clerical work involved in using the results is kept at a minimum.

Following is a description of the five tests which are recommended and a diagram of the floor plan used in these tests. It can be drawn on the gymnasium floor or playground with alabastine or some other inexpensive cold water paint.

TABLE 6

ROTATED FACTOR LOADINGS OF THE SECOND TWO FACTOR ANALYSES

	I	II	III	I	II	III
	BOYS			GIRLS		
5 Johnsons	.0204	1.0135	-.0204	.0535	.9969	-.0118
5 Johnsons weighted	.0299	1.0054	-.0594	.0787	1.0111	.0038
Weight	.7648	.2073	.2886	.5369	.0276	.2125
Right grip	.9223	.3364	.2038	.6644	.2137	.3208
Left grip	.6287	.3178	.2978	.6669	.2204	.3212
B	.1047	.6738	-.0266	.2523	.6286	-.0705
D	.0998	.6946	-.1363	.0824	.6292	-.1399
E	-.0454	.6742	.0725	.1621	.6638	.0137
H	-.0666	.7808	.0981	-.2206	.7034	.2101
I	-.0533	.7687	.1283	-.1555	.8161	.1658
Standing Broad Jump	.1554	.4624	.5864	.0267	.2908	.5423
30 Yards Dash	.1319	.4134	.5787	.1277	.3429	.5298
Run - over	-.0833	.2817	.6189	-.1247	.2386	.6171
Run - under	-.1045	.4000	.6337	-.0759	.2862	.6604
Run - sit	.1136	.3084	.4708	-.0435	.2022	.6582
Hop	.1493	.3889	.1493	.0798	.5498	.5089
Sargent Jump	.4869	.4687	.4869	.3084	.3747	.4092

[3] *"Standing Broad Jump" - Score in feet and inches.*
"Thirty Yards Dash" - Score in seconds from a regular start.
"Run and Over" - The child runs twenty-five feet, climbs over a wooden horse two feet high and four feet long, then runs back. A running start is used. Score is time in seconds from moment child crosses starting line until he recrosses.
"Run and Under" - The child runs twenty-five feet, climbs, crawls, or rolls under the horse (see above) and runs back. Scoring and start are the same as above.
"Run and Sit" - Child runs twenty-five feet, sits down on the ground, gets up, and runs back. Scoring and start are the same as above.
"Hop" - The child hops fifty feet on one foot. Score is time in seconds.
"Sargent Jump" - Wall chart method (3) is used.

TABLE 7

A COMPARISON OF THE CORRELATIONS BETWEEN THE FIVE JOHNSON TYPE TESTS WEIGHTED AND UNWEIGHTED AND THEIR VARIABLES

Boys		Events	Girls	
5 Johnson unweighted	5 Johnson weighted		5 Johnson unweighted	5 Johnson weighted
.3832	.3762	Right grip	.2367	.2378
.3169	.3105	Left grip	.1921	.2378
.3280	.3305	Grips	.2471	.2721
.2119	.2089	Weight	.0783	.0613
.7492	.6954	B	.6734	.5398
.7139	.7725	D	.6355	.6503
.7150	.7106	E	.7186	.6160
.8004	.7752	H	.7246	.7773
.7948	.7594	I	.8293	.7837
.4661	.4391	Broad jump	.3046	.2716
.4009	.4205	Dash	.3723	.3415
.2609	.2528	Run and over	.2314	.2926
.3985	.3667	Run and under	.2806	.3383
.2646	.2629	Run and sit	.1781	.2247
.5493	.5573	Hop	.5743	.5521
.4528	.4536	Sargent jump	.3909	.3849

1. Single hop left. (Originally designated as test B.) Hands on hips. Start with feet together behind the first white square on the left. Hop on the left foot onto the first white square, then onto the black square, the second white square, and so on down the mat.

2. Diagonal hop. (D) Start with the feet together on the first center target. Hop with feet together onto the first black square to the right, then to the second center target, to black square on the left and so on down the mat.

3. Backward hop right. (E) This test is the same as the single hop right except that the child hops backward. Hands on hips. Start with the feet together behind the first white square on the right. Hop on the right foot onto the first white square then onto the black square, the second white square, and so on down the mat.

4. Left sideward hop. (H) Hands on hips. Start with left side toward the mat, left foot on the center target. Hop on the left foot diagonally backward to the first black square then, still on the left foot, diagonally forward to the second center target, then diagonally forward to the second black square. Proceed thus along the mat.

5. Right diagonal hop. (I) This test is the same as number 4 except that it is done on the right foot and with the right side toward the finish target.

The tests are scored according to Johnson's directions. Ten is the perfect score from which is subtracted one point if the subject breaks his rhythm, one if he takes his hands off his hips, one for every time he steps over a line or fails to touch the square or center target as directed. He is also penalized a point if he hops forward instead of sideward in tests 4 and 5. If he makes more than ten errors, his score is zero.

Figure 1 gives the modified mat used for the Johnson type tests.

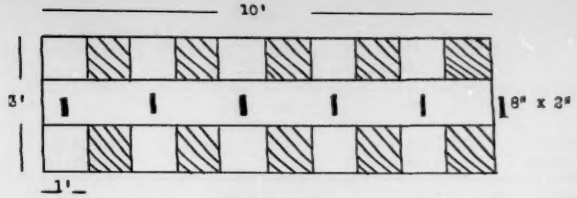


Fig. 1. Modified Mat Used for Johnson Type Tests

The five tests were combined for 213 boys and 217 girls of the first, second, and third grades. The combined scores were correlated with age for the sexes separately and from these were computed the following suggested norms:

Age	Girls	Boys
6	22.38	17.93
7	23.85	19.05
8	25.32	20.17
9	26.79	21.29
Standard Deviation of Estimate	6.39	7.67

While the number of subjects from which these norms were computed is inadequate, it is suggested that they may be used as a general guide until more work has been done. It will be noted that the girls exceed the boys at every age. A suggested explanation for this is that in general while the boys are playing other active games, the girls participate more in such individual activities as hopscotch and jumping rope.

The children enjoy doing the "stunts" involved in these tests. Furthermore, the classroom teacher herself can give the tests and in so doing she will observe more readily the individual differences of the youngsters. She will see that some need more help, more patience, perhaps more detailed directions and demonstrations while others grasp new motor ideas rapidly, coordinate readily and are soon looking for new worlds to conquer.

REFERENCES

(1) Johnson, Granville B.: Physical skill tests for sectioning classes into homogeneous units. Am. Phys. Ed. Assn. Res. Quart., 1932, 3, 128-37.

(2) Koob, C. G.: A study of the Johnson Skills Test as a measure of motor educability. Unpublished Master's Thesis, State University of Iowa, 1936.

(3) McCloy, C. H.: Tests and measurements in health and physical education. New York, F. S. Crofts and Company, 1939

(4) McGraw, Myrtle B.: Growth - A study of Johnny and Jimmy. New York, D. Appleton-Century Company, 1935.

(5) Thurstone, L. L.: The vectors of mind. Chicago, The University of Chicago Press, 1935.

(6) Wellman, Beth L.: Mental growth from preschool to college. J. Exper. Educ., 1937, 6, 127-138.

GHEE

COMMENTS ON "THE VARIETIES OF HUMAN PHYSIQUE"

HOWARD V. MEREDITH[1]

To an already extensive bibliography on attempts to describe and classify The Varieties of Human Physique, Sheldon and his collaborators have added a 1940 reference.[2] Publication of this book has been awaited for some time. It had been anticipated the book would represent the rigorous reporting of a first-class investigation.

The writer recently read The Varieties of Human Physique. Being actively engaged both in teaching and research relating to the physical growth of the child, he attempted to obtain a reasonable mastery of the book's contents. The task was found to be far from straightforward. At numerous points the report appeared unnecessarily vague or involved. Instances of seemingly ambiguous terminology, confused inference, and needlessly indefinite statement were found to occur with exceptional frequency.

The purpose of this paper is to cite some of the specific material which generated the above reactions, and to inquire whether or not the reactions of others concur. Clearly, then, the paper is not intended to constitute either a systematic review or a comprehensive evaluation. It is no more than a series of miscellaneous comments, addressed to individuals already familiar with the book itself, and directed toward greater clarity and precision in the planning and reporting of "constitutional" research.

THE DATA

Chapter III of The Varieties of Human Physique makes it clear that the major source of data for the investigation was 'the standardized photograph'. Detailed description is given of the equipment and technique employed to secure "exact frontal, profile, and dorsal" (p. 30) photographs of the whole body. It is stated:

> "...a series of standardized photographs of 4,000 undergraduate male students was collected at several mid-western and eastern universities. The ages of these subjects ranged *from 16 to 20, with the mean at 18 years, 3 months. In this series* the racial element was disregarded, except that Negroes and Orientals were not included" (p. 31).

The basic data were inspectional judgments derived from these photographs. In certain analyses the data were direct ratings from "picture-to-picture" comparison. In other analyses they were separate ratings for each of five regions of the body made with the aid of a check list. (This check list was an itemization of the morphological features found to characterize each of three extreme varieties of physique.)

Besides the reinforcement afforded by the check list, the inspectional data were supplemented with 18 anthropometric indices. These indices were

[1] From Iowa Child Welfare Research Station, University of Iowa, Iowa City, Iowa.

[2] Sheldon, W. H., with the collaboration of Stevens, S. S., and Tucker, W. B.: The Varieties of Human Physique: An Introduction to Constitutional Psychology. New York: Harper and Brothers, 1940. Pp. xii, 347.

CHILD DEVELOPMENT, Vol. 11, No. 4 (December, 1940)

based on "accurate measurements of height and weight for all the individuals whose photographs had been taken" (p. 50), plus "17 measurements of diameters" taken on the photographs. They represented all of the measurements except stature "expressed as simple ratios of stature" (p. 53).

Summarizing to this point, the basic data appear to have been inspectional judgments of photographs supplemented in part by a check list and in part by anthropometric indices. Analysis of these data ultimately results in a classification of the photographs into 76 physique groups - called somatotypes. Immediately prior to describing each somatotype, the investigators note that their descriptions include "some observations on non-photographable characteristics" (p. 141). The nature and scope of these observations are not discussed.

Proceeding to the descriptions one finds such statements as follow. The 172 "is almost always slow spoken and mild-mannered, and he is not often intellectually inclined" (p. 191). Nearly all the 424's "speak with delicate voice control, and with a voice that is notably sensitive to emotional influence" (p. 167). "The 532's are prone to eat gluttonously... Frequently they are heavy smokers" (p. 198). Do the data include records of speech, observations on eating and smoking, and ratings of manners and inclinations for each of the 4,000 subjects? To continue: "The 252 is...usually fast on his feet" (p. 193). "The 621's are inclined to exhibit great energy" (p. 207). The 117 is "a great walker... striding with a long, springy up-and-down motion" (p. 144). The 226 "walks rather awkwardly" (p. 151). The 127 "is fond of walking" (p. 145). The 162, though "built to stand punishment,...usually lacks the resiliency and the sustained endurance of the professional heavyweight athletes" (p. 188). "The 217 nearly always has poor muscular coordination" (p.147). "All the mesomorphic physiques carry predilection for muscular exercise" (p. 210). The "mesomorphic ectomorphs show an average BMR reading at least twenty points higher than...mesomorphic endomorphs" (p. 233). "...the ectomorph needs to eat oftener than the endomorph or the mesomorph" (p. 248). Certain classes of ectomorphs "seem to be peculiarly resistant to most of the contagious diseases" (p. 145). Extreme ectomorphs are "often singularly spry" (p. 32). The facial bones of the 533, "seen in an X-ray photograph", are slender (p. 185). The wrist bones of the 711, "seen in an X-ray photograph", are not large (p. 206). What are the foundations of each of these statements? Have the investigators accumulated and analysed data on their 4,000 cases from roentgenograms of the face and wrist, records of basal metabolic rate, observations on mode of walking, disease histories, and tests of coordination, strength and agility? From what sources, if any, do they draw data for statements such as: "The 117 and the 127 remain at nearly the same weight throughout life" (p. 148); "In the later decades, the 271's tend to grow heavy" (p. 208); Several classes of ectomorphs "are long lived" (p. 145)?

PURPOSE AND PROCEDURE

In Chapter I, the investigators supply the reader with a brief summary of their study. The opening paragraphs of this summary deal with the problem or purpose of the study. The first paragraph states that

the problem was that of "discovering[3] first-order criteria for the classification of human physiques," or of "finding those aspects of grading human physiques which will produce the most fruitful and 'meaningful' schema" (p. 4). The second paragraph, however, claims that "Three primary aspects of bodily constitution were selected[3] for study," this selection being based on the assumption that each aspect was "a component of structure - something which enters in different amounts into the making of a body" (p. 4). What was the purpose of the investigation? Was it first to describe and classify - and perhaps finally attempt to explain - the varieties of physique found in a large sample of white male undergraduates? Or, was it to attempt a classification and description of the physiques of college men in terms of an initially posited theory? The first paragraph appears to support the former purpose and the second the latter.

Careful examination of the procedure followed in the investigation appears to delineate, though not to resolve, this confusion. It will suffice to review a few of the initial steps. These were apparently as follows:

1. The full series of standardized photographs were examined and "precisely three" extreme variants of physique discovered (p. 31). One of these extremes showed "Rugged, prominent, massive muscling. Large, prominent bones." Thoracic volume predominant over abdominal volume. (p. 30) Another was characterized by "Roundness and softness of body." Absence of skeletal or muscular relief. "Predominance of abdomen over thorax." (p. 37) The third had "Small, delicate bones. Slight, 'thready' muscles." Flat thorax and abdomen. (p. 42)

2. The three extreme variations of physique are considered "fundamentally different" (p. 31) and "three elemental structural components are postulated" (p. 46). This postulate is elaborated as implying that the human physique is "made up of an intermixture of components" (p. 29) and every variety of human physique represents "a patterned mixture of these three more or less interdependent variables" (p. 47). At this point it apparently becomes the purpose of the study to determine "what combinations or patternings of the components actually occur in life" (p. 30) and to obtain "a descriptive classification of the patternings of the morphological components" (p. 31).

3. Detailed study was made of "one hundred relatively extreme samples of each of the three variants. These examples were selected by inspection from the 4,000 cases" (p. 30). The object of this step was "to record the characteristics of the three extreme variants, and thereby to define the three morphological components" (p. 30). It is emphasized that the listing of "the characteristics which distinguish the three principal types of male physique as they occur in extreme variations...was strictly empirical" (p. 45-46). Less explicit is the fact that there is transition from an empirical procedure to a rational procedure when it is inferred that the features listed define "basic components." [It should be noted here that in an earlier connection the investigators do state it is their "assumption" that extreme physiques are extreme "because they are dominated each by a different structural or morphological component" (p. 30).]

4. The next step was to arrange the photographs, successively, "in fifteen ascending series, each series based upon the inspectionally estimated value of one component in one bodily region [the body being divided into five regions]. The estimate of a component's value was based simply upon picture-to-picture comparisons in the light of" the lists of distinguishing features discussed above (p. 47). The implications of this procedure are not immediately apparent. The lists gave

[3]*Italics ours. The objective of "discovering" a schema is obviously not synonomous with that of studying a "selected" schema.*

only the characteristics of extreme physiques while the investigators set themselves the task of judging the "strength" of the components along three hypothetically continuous scales extending from these maximum expressions to undefined minimum manifestations.

5. It is difficult to determine the stage at which the investigators came to identify their three "components" with derivatives of the germinal embryonic layers. They introduce this identification prior to discussing their detailed recording of the body features of the extreme variants. Once, it is stated that the identification is "tentative" (p. 111). Elsewhere, however, the components are unreservably referred to as endomorphy, mesomorphy, and ectomorphy. The terms "endomorphic softness", "mesomorphic hardness", and "ectomorphic fragility" are coined and the report is saturated with phraseology like "endomorphic influence", "mesomorphic interference", "ectomorphic increment", "endomorphic set", "mesomorphic skin", "ectomorphic neck", "endomorphic shoulders", "ectomorphic tenseness", "endomorphic concentration", and "ectomorphic brittleness".

It is not necessary to review later steps of the procedure. These are sufficient to make it evident that the procedure involved repeated oscillation from observation to rationale, from description to assumption, from findings to theory. Can the study be regarded either as a straightforward attempt to test a hypothesis or as a rigorous approach to the formulation of a hypothesis? In the continual interplay of systematization of the data and "basic component orientation" (p. 238), which tends to predominate? Is the latter given the leading role and the former used mainly in a supporting manner?

ENDOMORPHY

The term endomorphy is used with the connotation that it constitutes a "basic component" of physique, "derived principally from the endodermal layer" (p. 5). Since the digestive viscera are the only derivatives of endoderm which can be considered to exert a marked differential influence on bodily configuration, the claim is made that "When endomorphy is dominant the digestive viscera are massive" (p. 5). The question now presents itself: Do the investigators base their estimates of endomorphy on determinations of the massiveness of the digestive viscera? Apparently not. At least no clear evidence is presented to show that those college students regarded as "extremes in endomorphy" had the most massive digestive viscera of the entire series. It is true that a student rated an extreme endomorph is described as having a "large and predominent abdomen" (p. 205). However, at least part of this extreme thickness of the "midsection of the body" is credited to "a great roll of fat over the symphysis" (p. 205). Support for the assumed relation between inspectional ratings of endomorphy and measurements of visceral mass rests mainly on autopsy data for intestinal length and weight obtained on thirty-four middle-aged males each rated as predominantly endomorph, mesomorph, or ectomorph.

On what basis then were the so-called "extremes in endomorphy" selected from among the four thousand college men examined? Principally, it appears, on the basis of abdominal bulk in combination with a heavy "overlying blanket of soft tissue and fat" (p. 205). This raises the question, how is it possible for the investigators to regard "conspicuous laying on of fat" (p. 34) as an expression of endomorphy? The answer is found in the fact that they shift their rationale of endomorphy from

structure to function. It is not claimed that subcutaneous tissue is a structural derivative of embryonic endoderm, but the claim is made that fat-deposit is "an indication of predominance of the absorptive functions - the functions of the gut" (p. 34). Have Sheldon and his collaborators overlooked that by the same rationale the absorptive functions of the gut are also basic in the production of mesomorphy, with its "large bones, big joints, and heavy muscles" (p. 32)? Moreover, is it not questionable - since Kretschmer is criticized for employing both structural and functional terms in his classificatory system - whether the authors clearly recognize that they view "endomorphy" partly as a structural derivative of endoderm and partly as produced with the functional assistance of endodermal tissues?

The physique designated 711 is evaluated as "a physique extreme in endomorphy and at a minimum in the other two components" (p. 6). When applied to standardized photographs of the body, does "extreme in endomorphy" mean anything more, or different, than extreme in thickness of subcutaneous tissue and abdominal mass? Were any non-photographic sources of data consistently employed? It is posited that endomorphy "is expressed in the skeleton, in the muscle...in the circulatory system ...and indeed in every tissue of the body" (p.224). What kinds of data and analysis, if any, do the investigators have to support this statement? Certainly it is not supported by their photographs for college men somatotyped 711, since here the reader is informed that whether inspection is made of the trunk region, the facial region or the extremities neither bone tissue nor muscle tissue "shows through". Turning from the matter of the precise meaning of "extreme in endomorphy", it is next pertinent to consider what is implied when the 711 physique is stated to be "at a minimum" in mesomorphy and ectomorphy. It appears improbable that the phrase "at a minimum" is based on any observed morphologic features of the college men to which it is applied. This follows, since in describing the 711's the statement is made that "neither musculatory nor ectomorphic interference shows through at any point" (p. 204). Do the investigators make the unwarranted inference that tissues sufficiently overlaid with subcutaneous tissue as to be no longer indicated are necessarily "at a minimum"?

It appears unequivocal that in describing the varieties of human physique, as in every other scientific pursuit, it is desirable to avoid ambiguous terminology and employ language that is as clear and precise as possible. From this standpoint, appraise the following series of "descriptive" statements. "The whole body [of the 632] is deeply swathed in an endomorphic blanket" (p. 201). The 252 has "a perfect diffusion of the soft endomorphic element throughout the body" (p. 193). In the 452 "There is a softening endomorphic suggestion about the cheeks" (p. 201). The 353 shows "little sign of any special endomorphic fullness over the deltoids" (p. 185), while the 533 is characterized by fairly marked "Endomorphic inflation at the deltoids" (p. 186). "In the 217 the iliac crests are typically covered by a thin endomorphic blanket" (p. 146). The 217 has "just the beginning of endomorphic inflation over the proximal segments of the upper arms" (p. 147), the 362 has an "unmistakable endomorphic suggestion in the upper thighs" (p. 200), and the 434 sometimes has "highly endomorphic legs" (p. 170). In the 532 "there

is a pronounced endomorphic inflation of both thighs and upper arms" (p. 198), whereas in the 126 "neither arms or legs show any trace of endomorphic padding or inflation of the proximal segments" (p. 149). In the 325 "the ankles are sometimes swathed in an endomorphic blanket" (p. 161), while in the 711 "The soft endomorphic blanket covers both the wrists and the ankles" (p. 206). Do the investigators intend these statements to describe anything other than thickness of adipose tissue? If not, what are the advantages of terming a thick deposit of subcutaneous fat a deep endomorphic blanket? In what respects is it in the interest of clear understanding to refer to a physique which appears "completely clean of fat" as manifesting no trace of "endomorphic padding or inflation"? Along a scale of degrees of thickness, are there zones which can be appropriately labeled "suggestion", "fullness", "accumulation", "swathed", "perfect diffusion", "trace of padding", "marked expansion", "pronounced concentration", "great inflation"?

Certain physiques are described as having highly endomorphic shoulders, shoulders with an endomorphic set, or chests distinctly endomorphic in shape. The shoulders of the 542 "are high, with a tendency toward endomorphic squareness" (p. 202). In the 524 "The shoulders have a distinctly endomorphic set" (p. 169). The 613 shoulders are "highly endomorphic (nonprojecting)" (p. 176). "The 424 generally has endomorphic shoulders, i.e., shoulders that are high and square and soft, and that do not protrude laterally much beyond the line of the trunk" (p. 167). In the 522 "The rather large chest is of distinctly endomorphic spherical shape" (p. 194). Why is the term "endomorphic" attached to otherwise clear statements regarding chest shape, shoulder slope, and shoulder projection? Have Sheldon and his collaborators formulated a reasonable hypothesis regarding the relation between derivatives of the endodermal layer and configuration of the upper trunk which they have omitted to present?

ECTOMORPHY

It has been noted earlier that a second of the three elemental components assumed to be intermixed in every human physique is termed ectomorphy. This term, obviously, refers to some sort of entity related to the embryonic ectoderm. What is the nature of this entity or component? Is it a morphologic derivative, a physiologic secretion, a physical radiation? Does it operate selectively or pervasively? That is, does it influence certain segments of the body or all segments; certain organs or all organs; selected tissues or all tissues; selected segments, organs, or tissues at certain ages and other segments, organs, and tissues at other ages? Such questions are, of course, too broad in scope to expect them fully answered by a single study. Are they not, however, such questions as those who wish to assume the existence of the component may reasonably be expected to discuss?

Sheldon and his collaborators state that with increasing degrees of "ectomorphic dominance...the skin and its specialized derivatives predominate over the internal structures" (p. 35). Dominance, in this instance, appears to have a different meaning than that given in the case of endomorphy and mesomorphy. Extreme mesomorphs are claimed to have

more massive bones than individuals low in mesomorphy, and extreme endomorphs to have longer intestines than individuals low in endomorphy. Extreme ectomorphs, however, cannot be claimed to have either a greater amount of skin or a larger nervous system than individuals low in ectomorphy. Consequently, ectomorphic dominance is interpreted not in absolute, but in relative terms. It is "Relative to total bodily mass" (p. 35) that the surface area of the skin and the nervous system are considered dominant. What, then, is the role of the component called ectomorphy? Is it passive, so that the extreme ectomorph is essentially the product of minimal massiveness of bone and muscle tissues and of visceral and adipose tissues? Stated differently, if ectomorphy cannot be shown to manifest itself in varying degrees through the derivatives of ectoderm is it justifiable to assume its existence? Does "ectomorphy" appear to represent a unique structural component which expresses itself in a continuous distribution, or, does it appear to reduce to no more than the slender end of a series of physiques that progressively diverge toward muscular and thoracic stockiness or adipose and abdominal stockiness?

The investigators make the claim their study yields components "which can be isolated in description and gauged in terms of scales" (p. 219). In the case of ectomorphy there is no serious attempt either to describe derivates of ectoderm in college men or to scale any of them. The only approach toward scaling of an ectoderm derivative has reference to skin thickness and texture. This crude grading is made not in terms of the hypothetically continuous variable termed ectomorphy, but in terms of variation between ectomorphy, mesomorphy, and endomorphy. Thus one reads that ectomorphic skin is "thin and dry...resembling the outer skin of an onion" (p. 44), endomorphic skin is "soft, smooth, and velvety, resembling the skin of an apple" (p. 38), while mesomorphic skin is "thick and coarse with large conspicuous pores", resembling the skin of an orange (p. 41).

Descriptions of the different varieties of college-male physique, incorporate such statements as, "ectomorphic triangularity in the face" (p. 195), "the thin sensitive lips of ectomorphy" (p. 197), "ectomorphic tenseness in this face" (p. 203), "ectomorphic neck" (p. 250), "an ectomorphic stoop to the shoulders" (p. 178), "ectomorphic flattening of the upper chest" (p. 178, 187), "ectomorphic brittleness in the distal segments" (p. 195), "ectomorphic fragility...linearity, delicacy, and sensitivity" (p. 179, 171). What meaning accrues from the word "ectomorphic" when it is used to qualify triangularity or flattening or linearity?

SHOULDERS AND HIPS

Turning from questions of rationale to more objective items, one is still confronted with a large number of ambiguities. Many of the statements describing hips and shoulders are either open to more than one interpretation, or, cast in an indirect and indefinite style. Examples are:

1. In the 163 physique "The hips are relatively narrow" (p. 175). Likewise, in the 361 (p. 210). To what does "relatively" refer in these connections? Are the hips narrow with reference to stature, to width of thorax or to shoulder

width?[4] Similar questions arise when shoulders are described as "relatively narrow" in the 623 (p. 180), "relatively broad" in the 162 (p. 189), and "relatively wide" in the 621 (p. 207).

2. The shoulders are "extremely wide" in the 172 (p. 191), "on the broad side" in the 343 (p. 181), "wide" in the 352 and the 245 (pp. 197, 162), "not wide" in the 442 (p. 199), "fairly broad" in the 145 (p. 156), "of medium breadth" in the 434 (p. 170), "rather narrow" in the 533 (p. 185), and "narrow" in the 613 (p. 176). The hips are "broad" in the 631 (p. 211), "often wide" in the 415 (p. 157), "of moderate breadth" in the 442 (p. 199), "on the narrow side" in the 352 (p. 197), "typically narrow" in the 244 (p. 166), "rather narrow" in the 451 (p. 213), "narrow" in the 162 (p. 189), and "sometimes extremely narrow" in the 154 (p. 165). Do these statements have reference to actual size (i.e., absolute magnitude)? They appear to. Yet earlier in the report the investigators claim that in their system of somatotyping "absolute size...is canceled out of the reckoning" (p. 53).

3. In the 534 physique "The shoulders are not narrow, but they seem rather narrow, for the trunk as a whole is wider in comparison with the shoulders than is usually the case" (p. 174). Is this an indefinite way of stating that relative to stature the shoulders are not narrow, but relative to trunk width they are moderately narrow? Again, in the 354 physique "The hips seem comparatively narrow because of the wide shoulders, but they are not actually narrow" (p. 172). Is the first part of this statement an indirect way of describing hips that are narrow relative to shoulders? In the latter part of the statement what is the word "actually" intended to imply? Are the 354's 'not narrow' in absolute hip width or in hip width relative to stature? (Table 35, on page 281, appears to indicate that in the typical 354 college male hips are moderately narrow relative to stature.) Would it not be advantageous to report findings such as these positively rather than negatively, i.e., to describe shoulders and hips as "wide" or "average" rather than as 'not narrow'? Furthermore, would not the value of the study be greatly enhanced if its findings were reported more specifically, e.g., in college men classified as having a 354 physique, the ratio of hips to stature varied between 18.8 and 19.4?

MISCELLANEOUS AMBIGUITIES

A selected list of other statements considered seriously lacking in precision is as follows:

1. In the 145 physique "The trunk is of variable length, but on the average it shows about the aesthetically popular proportion to length of limb" (p. 156). What is the "aesthetically popular proportion" of trunk length to limb length? Again, part of the description of the 244 reads "There are no morphological peculiarities to mark this physique as departing from good conservative masculine taste" (p. 166). Why introduce such an undefined phrase as "good conservative masculine taste"?

2. "The 162 suggests strength, with little weakening at the extremities of the arms and legs" (p. 188), while in the 326 "The chest is relatively weak... weakness is seen in the inner aspect of the lower thighs...and the forearms and lower legs appear particularly weak" (p. 155). Why not describe structure in structural terms? What are the morphologic hall-marks of "strength"? What are the specific criteria of chest weakness, forelimb weakness, and thigh weakness? What distinction is intended when reference is made to "a slight slendering, rather than a weakening, of the wrists and ankles" (p. 189)?

3. The 145 is "a fairly rugged and muscular youth who is also markedly lean and brittle in appearance" (p. 156). In what sense may a physique be considered

[4] *Since at one stage of the study ratios of hip width to stature were calculated, the initial assumption of the reader is that whenever "relatively" is used in describing hip width it implies 'relative to stature'. On reading passages like "The hips [of the 171] are relatively narrow when compared with the shoulders" (p. 204), this assumption becomes untenable.*

both "rugged and muscular" and "lean and brittle"? In the 126 "The extremities appear fragile and brittle, but the physique as a whole suggests action, speed, and clean quick movement. This is a tense and unrelaxed, if not an unrelaxable, physical constitution" (p. 148-149). Given standardized photographs of individuals standing in the erect position, what are the indicators of brittle extremities, unrelaxable constitution, and tendency to quick movement?

4. In the 316 physique "The back is weak, waist high, and the hips wide. The lower legs and arms look like slender stilts which are strikingly white and appear devoid of muscle" (p. 153). What are the structural earmarks of a weak back? Is the waist high in relation to stature, trunk length, or both? Are the hips wide in relation to stature, to shoulder width, or to the hip widths of other college men? By what clues may one recognize forearms considered "devoid of muscle" - are the shafts of the radii thrown into relief?

5. "The 335 is still a pronounced ectomorph but the sharpness of feature and the lean sensitivity of the body are blanketed with a softening first component like a rock quarry with a carpet of snow" (p. 162). What is "lean sensitivity"? In the 612 "The arms hang loosely and nervelessly, like useless flippers" (p. 190). "In the endomorphic 7's the arms and shoulders are relatively insignificant appendages, like those attached to rubber dolls" (p. 209). The face of the 261 "suggests the resilience and toughness of high-grade solid rubber" (p. 206). Are any of these analogies compatible with the level of exactitude which research on human morphology reasonably can be expected to attain?

6. Reference is made to the 345 youth "who in his teens looks more ectomorphic than he is" (p. 163). If interpreted as a comparison of the 345 physique at different ages, this statement appears to imply that the 345 is more ectomorphic in his teens than he is as a young adult. If interpreted as applying exclusively to the teens it appears to say nothing more than the 345 youth looks more ectomorphic than he looks. While the latter interpretation yields a self-contradiction, it also appears unlikely that the former is intended since the investigators state elsewhere, "the impression appears warranted that the somatotype is definitely fixed before birth" (p. 158). Is there a third alternative? Might the statement be interpreted to mean that standardized photographs of the 345 "in his teens" are judged differently at first glance than after more thorough inspection?

7. In the 325 "the shoulders are relatively narrow and often drooping, the chest is more or less slumped...and the wrists are likely to seem extremely slender" (p. 161). "The 425 is a stronger and less collapsed 415... The extremely weak neck, fragile facial structure, collapsed chest, and narrow shoulders of the 415 have all been somewhat strengthened, but this is still a weak physique. There is general relaxation and the suggestion of flaccidity throughout" (p. 162). Italics ours. Is such indefiniteness unavoidable in research on the variations of human physique?

SUMMARY

A study on The Varieties of Human Physique was recently reported by Sheldon, Stevens and Tucker. It is the purpose of the present paper to place some comments on this study before the readers of Child Development. The comments are organized under six selected headings: The Data, Problem and Procedure, Endomorphy, Ectomorphy, Shoulders and Hips, and Miscellaneous Ambiguities. They are made with the sole intent of stimulating greater clarity and scientific rigor in the research area to which they apply.

BILATERAL MANUAL PERFORMANCE, EYE-DOMINANCE AND READING ACHIEVEMENT

GERTRUDE HILDRETH[1]

This study reports the performance of young children in using both hands simultaneously for copying figures. The data obtained in the experiment reveal the developmental trends in this performance through several successive age groups and shed some light on the relation of handedness, eyedness and reading performance. The method offers new possibilities for research in child development. It has previously been shown by Van Riper (2) and others that simultaneous bilateral drawing gives a reliable measure of handedness.

Some years ago Fuller (1) effectively demonstrated that simultaneous writing or drawing by the two hands is naturally identical but opposed. The natural orientation of the two hands is isotropic with reference to the body axis. In mirror-writing the kinaesthetic sensations agree with those of the correct writing with the dominant hand. In the normal right-handed person, mirror writing with the left is the typical automatic motor expression involving only the primary central motor apparatus. Mirrored left-handed script is normal for the young, dull, untaught person, or one who is responding automatically, rather than on an attentive level. The neural-muscular apparatus favoring reversals or mirroring is therefore always potentially present. Reversing the direction of the two hands in drawing the same figure simultaneously is a normal performance. The higher intellectual processes can inhibit this tendency, through learning or conscious attention. The unilateral movement when the two hands function together in drawing is the result of training, insight and sophistication.

The left and right orientation of objects in space is naturally elusive. Correct orientation is difficult for young children to acquire. Confusion may persist for years in spite of systematic training, but practice ordinarily helps establish correct orientation habits. Visual and kinaesthetic learning are involved in acquiring the correct eye-hand coordinations.

THE EXPERIMENT

The test used was constructed for purposes of the experiment. Fifteen figures were drawn on white flash cards measuring approximately four by ten inches, one figure on each card. (See Figure 1). The last four figures contained familiar letters and numbers. The others were meaningless symbols. The first item was a square. Each child was tested individually. The child was seated before a board to which ordinary letter sized paper had been clipped, after being ruled down the center. He was told that he would be shown a series of pictures on the white cards, and that he was to attempt to copy each figure using both hands at once, and pencils of equal length and sharpness. He was instructed to keep the

[1] *From Lincoln School of Teachers College, New York, N. Y.*

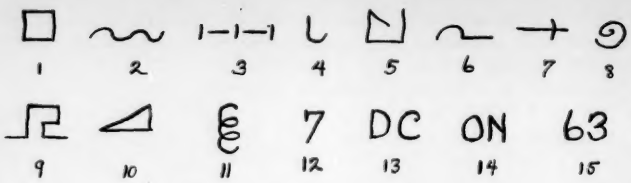


Fig. 1. Figures used in the Bimanual Drawing Test

drawings of one hand on the right side of the vertical line, drawings of the other hand on the left.

As each child worked the examiner made marks on the child's paper indicating the direction in which the drawing with each hand was done. The flash card for each succeeding test served as a screen to prevent the child from observing that such marks were being made.

This was a new experience for all of the children and naturally difficult for the youngest nursery school and kindergarten groups. The great advantage of the test is that it was a novel experience for the child and enabled the examiner to observe the performance of the two hands simultaneously under identical conditions.

For testing eyedness two methods were used: Parsons Manoptscope: an aluminum cone placed over the eyes, with an opening at the smaller end, which the subject directs toward the object of vision. The peephole method was used as a check test. A cardboard containing a quarter inch hole was held before the subject's eyes by the subject himself, and was fixated on another card at several feet distance, containing a black ink dot. The position of the card over the subject's eyes, indicated right or left-eyedness. Both tests are somewhat subject to hand dominance, unless unusual precautions are taken in examining.

Handedness was judged from the performance on the bimanual copying test, and teachers' observations. A child was rated as right handed who used the right predominately in unilateral activities, e.g., writing, ball throwing, eating.

Reading was checked systematically at the end of the school year with routine school tests, part of the regular achievement testing program. Although the same tests were not used at different grade levels, grade scores made it possible to compare results.

The total number of children tested was 103, 57 boys and 46 girls, in six groups ranging from nursery level to third grade, in age from four to nine and a half, all the cases that were available at the time in the school.

The children were above average in height, weight, economic and social status, intelligence, social background, and they were all in good health.

Scoring. Children's responses were scored in four categories: 1. Item correct, movements in drawing made simultaneously and identically. 2. Mirrored or reversed result, full or complete reversal. The drawing pattern of one hand the opposite of the other. 3. Partial mirroring or figure reversal. 4. Other response involving some error.

Results for all the varied types of error were not fully analyzed, since I was not so much concerned with exactness in drawing as in the reversal or mirroring feature of the drawing activity.

A "reversal" in a unilateral figure or a bilaterally symmetrical figure such as a square can be noted only in terms of the movement of the hands in drawing it, not in the way the figure "faces" after it is completed. This is the case with items numbers 1, 2, and 3; and the "0" of number 14.

Children's Reactions to the Test. The children were naturally curious about the test. Most of them thought it had something to do with determining which hand was better. One boy of eight asked, "Is it a test of ambidexterity?" Another, "Isn't it for nervous reactions?" Most of the older children tried to identify the figures as something familiar. This seemed to make the drawing task easier.

In the course of testing, differences in personality showed up. It was possible to observe disorganization and disintegration, resistance, mental dullness. The learning process during the test was interesting to observe.

Results. Three children in the nursery group had non-scorable papers. All others could be rated according to the scoring scale developed. The hands of the younger children sometimes tended to separate during the drawing, and the results thus produced were counted wrong. Actually there was less mirroring when the hands performed separately.

Bilateral Score in Relation to Age

Age	Average Score: Correct	Mirror or Reversal	Part Reversal	Other	Number of cases
Under 5	1.43	3.29	.715	5.14	7
5 to 5-11	3.89	6.91	3.085	1.16	14
6- to 6-11	7.94	5.05	1.28	.61	18
7 to 7-11	10.4	3.78	.66	.01	27
8 to 8-11	10.5	3.22	1.26	.002	27
9-0 to 9-6	13.7	1.			13.

Mirroring was quite universal among the five-year-old children. The mirroring seemed to be a very natural performance. There was little evidence of conscious effort to make both hands move in the same direction.

The mirror tendency, however, steadily declined with age. The number of partially mirrored items and other errors also declined. The oldest group had almost perfect papers.

Sex Differences. Do boys show more natural mirror tendency or more confusion than girls? Since the number of boys and girls was similar and the age distribution in the two groups about the same, a comparison was made of scores for the two groups.

Sex	Average Correct	Mirror: Number of cases	Average Reversed	Number of cases
Boys	8.4	56	4.7	55
Girls	9.06	46	4.21	41

The scores show only a negligible difference in favor of the girls in the number of perfect drawings made on the average. Girls tended to make slightly fewer mirror responses.

SUMMARY FOR THE FIFTEEN SEPARATE FIGURES

Do some items in the series cause more difficulty than others? We can not know the absolute difficulty of the separate items without giving the items again in rearranged order, and this has not yet been done.

What was the difficulty order as the series was presented in this experiment? The following table shows the number of times each item was correct or reversed.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Correct	19	50	39	75	74	72	55	58	64	84	66	74	69	54	66
Reversed	79	48	55	20	20	23	41	36	23	22	20	23	1	2	2

In order of frequency, number correct and number reversed, the results are as follows:

Correct - 10,4,5,12,6,13,15,11,9,8,7,14,2,3,1
Reversed - 1,3,2,7,8,9,12,6,10,4,5,11,14,15,13

The item most frequently correct in all papers was the tenth, a triangle; the item most frequently reversed was the first, a square. The order in which the item occurred was probably a function of difficulty. All the earlier items were more frequently mirrored than the later items, yet intrinsically they were not more difficult.

Improvement was frequently shown in comparing the last half with the first half of a subject's performance. This tendency to improve in the test itself steadily increased through the age groups up to the point where there was little room for improvement.

Orientation, left or right, may be a more subtle feature of the square because it has no obvious direction as an object such as a triangle or other lopsided figure would have. The curved and closed items seemed to lend themselves more to mirroring than other items. The familiar letter and number items (except for ON) were easier, and the simpler, unfamiliar figures appeared to be easier and less subject to reversals.

Items 11 and 9 were hard items because of relatively complex motions needed in performance. On these items the children studied harder and made more conscious effort to draw correctly. Figure 10 was easy to draw.

DIRECTION OF MIRROR ORIENTATION

When reversible figures are mirrored in which direction, right or left are they reversed?

Of all items mirrored, 191 in all, 152 items showed left mirroring, left hand figure inverted, only 39 right mirroring, right handed figure inverted. Furthermore, left mirroring tended to increase in the older age groups. Four times as many figures were mirrored to the left than to the right. This mirroring was done by the left hand in practically all cases.

The Factor of Intelligence. What is the association between intel-

ligence and mental maturity to these scores? Through all the age groups, the scores, on the average, of children under 112 I.Q. were compared with those rating over 125 I.Q. on the Stanford Binet test. This variation in I.Q. was chosen so as to have an adequate number of children and an equal number in the two groups.

Results	Correct	Mirror or Reversal	Part Mirrored	Other	Number
I.Q. over 125	10.6	3.2	1.17	.2	23
I.Q. under 112	7.05	4.4	.9	2	22

There is some relation between lack of mental maturity and mirror tendency in this test; between success and ability. A wider ability range would probably tend to show still more difference. Our results are doubtful because of the small number of cases. Our clinical observation of the children at work proved that the immature children whether young or comparatively dull had more difficulty with the test than older and brighter subjects.

Relation of the Bilateral Test Scores to Reading Achievement

Grade Score in Reading	Correct	Mirror or Reversal	Part Reversal	Other	Number
No reading skill	2.94	5.65	2.2	2.5	17
1.1-1.5	6.41	5.67	1.17	1.8	12
1.6-2.5	8.07	5.42	1.33	.15	14
2.6-3.5	8.5	4.45	1.75	.25	18
3.6-4.5	11.55	2.7	.62	.04	16
4.6-5.5	10.25	3.17	.75		12
over 5.5	12.9	1.5	.5	.08	12

These results show a gain in the drawing test scores and reading achievement up to the fourth grade level. It is reasonable to suppose that the steady practice in left to right orientation that successful reading achievement affords would help in overcoming natural mirror trends, but the relationship suggested in this table may be associative rather than causal.

COMPARISON OF SCORES, RIGHT- AND LEFT-HANDED SUBJECTS

Do left-handed children show more mirror and reversal tendency than right-handed children? The number of cases of left-handed children was small, 14 or 13 per cent in all the groups. This included those who were left-handed at the time of the test, or were reported to have been left-handed formerly and to have been shifted partially.

These cases were matched for age, sex and I.Q. with subjects who proved to be right-handed at the time of the test and were reported always to have been right-handed.

One and a half times as many items were mirrored by the small group of left-handed subjects compared with a matched right-handed group.

	Results		Test Scores		
	Average Correct	Average Mirror	Average Part Mirror	Other	No. of cases
Left hand	9	4.7	1.14	.14	14
Right hand	11.7	3	1.14		14

Most of these children are not clear cases of left-handedness, but had been shifted to right, especially for writing activities, hence they might tend to suffer more orientation confusion than other children. Several cases of left-handed children who had never been shifted did little mirroring.

EYEDNESS AND BILATERAL TEST SCORES

What is the relation between the drawing test scores and eyedness as measured by appropriate tests?

RESULTS

Eyedness - Both tests, Manoptscope and Card

	Right (both)	Left (both)	One test right, one test left
Percent	49	39	12

Manoptscope only (the more reliable test since it is less affected by handedness)

	Right	Left
Percent	52.3	47.7

Trends were similar from group to group with both tests. Handedness appears to affect these results to some extent.

RELATION OF EYEDNESS TO HANDEDNESS

Right and left eyedness was almost evenly divided among good and poor scorers on the test. No association could be discovered between eyedness, left and right, and score on the drawing test.

CONCLUSIONS

1. The Bilateral Drawing test results prove that unilateral orientation in drawing when the hands perform simultaneously is a function of mental development and maturity. This orientation is achieved in part through practice and learning, through conscious effort. It in time surmounts the more natural automatic tendency to move the hands in opposite directions when drawing simultaneously. The vanishing point for this type of error may not be reached until adulthood, but nine year old bright children are rapidly approaching maturity in this respect.
2. Simpler figures and those more closely related to writing practice cause less error and mirror tendency than other more complicated or unpracticed figures.
3. Confusion due to shifted handedness may prolong the mirror ten-

dency. In the older child reversals are significant of immature orientation.

4. The tests prove useful in clinical diagnosis, first for detecting manual dominance with more accuracy, and second in studying the individual child's developmental status in manual orientation. We advocate its use with all handedness problems and children who seem confused in reading and writing. Similar studies should be carried on with children of average intelligence in all age groups.

REFERENCES

(1) Fuller, J. K.: The psychology and physiology of mirror writing. Univ. California Publ. Psychol., 1916, 220-240.

(2) Van Riper, C.: The quantitative measurement of laterality. J. Exper. Psychol., 1935, 18, 372-382.

THE PLACE OF STATISTICS IN STUDIES OF CHILD DEVELOPMENT[1]

EDWIN B. WILSON[2]

When Dr. Stuart asked me many months ago to say something at this meeting of the Society for Research in Child Development about the place of statistics in their work I supposed that I should be tucked in somewhere in a session attended chiefly by statisticians and others who were primarily interested either in statistical methods or in the results of their applications. It came therefore as a surprise, if not as a shock, to me to learn relatively recently that I was to be an evening after dinner speaker. Only once I believe have I had to serve in that capacity with a scientific and technical discourse. That was when in 1927 at Cincinnati I gave at the request of Dr. George Kline, our Commissioner of Mental Diseases in Massachusetts, the Presidential Address before the American Psychiatric Association. It seems that that association is so sane that they have the President's address given by a guest speaker. Some of the members certainly enjoyed my address - they told me so, and I am sure some of them must have spoken truly for I had noticed them sound asleep.

We tend to drive very hard here in America. It may be doubted whether it is hygienic to finish off six hours of scientific sessions with a continuation thereof in the evening when you have to face six hours more on the morrow; but hygienic or not it is our wont. And that I suppose is the life for which you are developing these children whom you study. You are particularly bears for punishment when you venture upon a discussion of statistics after so many weeks of the strident shrieking of statistics in the papers and over the air in one of those long drawn out quadrennial contests before the American Electorate. I could well imagine that you had had enough of the subject. Wasn't it Mr. Roosevelt who spoke of the cruel Republicans which left the farmer 10 cent corn and 20 cent wheat? And did not Mr. Hoover answer him that it was 35 cent corn and 60 cent wheat? And did he not go on to say that when Mr. Roosevelt spoke of 20 cent wheat instead of 60 cent wheat he was 300 per cent wrong and 350 per cent wrong on the matter of corn? Which of the two is the better or the worse statistician, I do not know. There are many prices of wheat and corn according to time and place. Was one referring to prices on the farm and the other to prices in Chicago - were the times also different? I do not know. You do not care.

Seeing, however, that we are speaking of statistics did you stop to wonder how anybody could be 300 per cent wrong if the price of wheat really was 60 cents, except as he stated the price to be $2.40. But you must readily admit that 300 per cent sounds a deal more serious than 66-2/3 per cent, and that the prime purpose of a political campaign is perhaps not so much truth as success. For that reason I will not further pursue the deluge of numerical so-called facts which has recently been poured out upon us. I wonder how many of the electorate are deceived by such facts - or even pay any attention to them.

[1] *Address presented at the dinner of the Society for Research in Child Development, in connection with the Fourth Biennial Meeting of the Society at Harvard Medical School, Boston, Massachusetts, November 8-9, 1940.*

[2] *Professor of Vital Statistics, Harvard School of Public Health.*

Not all our facts come to us in numerical form. There are clinical observations which are expressed in words like many historical occurrences. Did you for instance hear the impressive voice from the Hollywood for Roosevelt program quoting with emphasis Geo. Washington's letter to Lafayette? "There are other points in which opinions would be more likely to vary. As for instance, on the ineligibility of the same person for president, after he should have served a certain number of years. Under an extended view of this part of the subject, I can see no propriety in precluding ourselves from the services of any man, who in some great emergency shall be deemed universally most capable of serving the public." As the program went off so rapidly I cannot say just how much of the appropriate passage from this letter was quoted. Let me give you the whole of it.

To Marquis de Lafayette — Mt. Vernon, 28 April, 1788

"There are other points in which opinions would be more likely to vary. As for instance, on the ineligibility of the same person for president, after he should have served a certain number of years. Guarded so effectually as the proposed constitution is, in respect to the prevention of bribery and undue influence in the choice of president, I confess I differ widely myself from Mr. Jefferson and you, as to the necessity or expediency of rotation in that appointment. The matter was fairly discussed in the convention, and to my full conviction, though I cannot have time or room to sum up the argument in this letter. There cannot in my judgment be the least danger, that the president will by any practicable intrigue ever be able to continue himself one moment in office, much less perpetrate himself in it, but in the last stage of corrupted morals and political depravity; and even then, there is as much danger that any other species of domination will prevail. Though, when a people shall have become incapable of governing themselves, and fit for a master, it is of little consequence from what quarter he comes. Under an extended view of this part of the subject, I can see no propriety in precluding ourselves from the services of any man, who on some great emergency shall be deemed universally most capable of serving the public."[3]

That looks tolerably convincing. Washington was not against any third term - at least not when he was writing this to Lafayette. The date shows that the letter was written during the time between the constitutional convention and the adoption of the constitution by the States. Washington was then devoting his energies to its adoption by the States. He had had no experience in the Presidency. He was admitting that the constitution was not perfect, that it could be amended, but was holding that first of all it should be adopted so that the government of the country could get going. It might be possible in view of many considerations to claim that he had just got into the habit of defending the constitution to forward its adoption and that he did not take very seriously his position against limitation in the total term of office.

However that may be, did you receive as I did from some unknown person a copy of the cogently written address of President Wriston delivered under the auspices of the associated Willkie Clubs of Rhode Island? Dr. Wriston, you know, was a student and teacher of history in earlier times before he came to preside over our neighboring institution with its strong department of history and its excellent historical collections, particularly Americana. Let us hear Dr. Wriston:

[3] *W. C. Ford, Writings of Geo. Washington, vol. 11, p. 257.*

"George Washington established the two term precedent. He knew that what he did would determine the pattern of procedure under the Constitution. He felt a deep sense of responsibility not to set bad precedents. Being a thoughtful and careful man, he took advice, and weighed it with the greatest care. The matter of accepting re-election was no exception and he decided against a third term not only on personal grounds, as has so often been said, but on grounds of public policy. What were these grounds?

"Washington said that a change in office of president was "more congenial with --- liberty and safety". So fully was he persuaded of that fact that he preferred one term to two and would not consider a third term under any circumstances, though he could have had it without asking."

I must not quote more of this very convincing address. You see Washington was unalterably opposed to a third term and even preferred one to two. Do you bet on Washington to Lafayette and Hollywood for Roosevelt or Dr. Wriston with his quotation, the source and date of which was not given though doubtless known to all historians and certainly not difficult for anybody to run down. At the risk of boring you I will tell you where it comes from. Early in the fourth year of his first term Washington told several intimates that he did not wish a reelection and he was turning over in his mind the substance of a farewell address which he wished to make on retiring from public office - as he had made one in retiring earlier from the highest military office. On May 20, 1792, about four years after his letter to Lafayette, he wrote to James Madison sending him a long but rather sketchy draft of his farewell address and asking him to look it over, suggest changes, or recast it as he saw fit. But let Washington speak for himself:

To James Madison — Mt. Vernon, 20 May, 1792

"---as the recess may afford you leizure, and I flatter myself you have dispositions to oblige me, I will, without apology, desire --- that you would turn your thoughts to a valedictory address from me to the public, expressing in plain and modest terms, that having been honored with the Presidential chair, and to the best of my abilities contributed to the organization and administration of the government --- and the spirit of the government may render a rotation in the elective officers of it more congenial with their ideas of liberty and safety; that I take my leave of them as a public man."[4]

I will not quote this letter further. It makes interesting reading for itself and for its comparison with the revised draft which Madison prepared. Whether now in May 1792 Washington really meant to state solemnly that the spirit of the government may render a rotation in the elective officers of it more congenial with their (the public's) ideas of liberty and safety, I do not know. He had had three years of actual experience as president and there is some evidence that he had run into some unexpected and unhappy experiences which may well have caused him substantially to revise that full conviction which he had from the fair (but theoretical) discussions in the convention. At any rate Madison took him literally at his word and in his draft put the matter as follows:

[4] *W. C. Ford, Writings of Geo. Washington, vol. 12, p. 126.*

To Geo. Washington Orange June 31, 1792

"May I be allowed further to add, as a consideration far more important, that an early example of rotation in an office of so high and delicate a nature may equally accord with the republican spirit of our Constitution, and the ideas of liberty and safety entertained by the people.

"Under these circumstances a return to my private station, according to the purpose with which I quitted it, is the part which duty as well as inclination assigns me.---"[5]

Washington did not complete his farewell address at this time, he was persuaded to permit himself to be elected for a second term. Early in the fourth year of that term he again took up the matter. At this time Madison seemed not to have been so close to him; he sent Madison's draft, with a preamble added and with other modifications, to Hamilton with a request for suggestions, even extending to a recasting of the whole. One of the modifications consisted in leaving out the paragraph: "Under these circumstances a return to my private station, according to the purpose which I quitted it, is the part which duty as well as inclination assigns me.---" He did not, however, delete or modify the preceding paragraph: "May I be allowed further to add, as a consideration far more important, that an early example of rotation in an office of so high and delicate a nature may equally accord with the republican spirit of our Constitution, and the ideas of liberty and safety entertained by the people." Four years more of practical experience in the presidency found that still standing.

If you are still betting on Dr. Wriston you might like to reflect on the fact that in the final draft of the Farewell Address the paragraph on rotation in office does not appear. Why? Because Washington had not come to believe in it? I do not know. He was working with Hamilton who probably did not believe in it. Had Madison worked up the paragraph merely out of deference to Washington's suggestion or partly because he himself believed in rotation? I do not know. I am not a historian. It is too much for me to weigh and I am not sufficiently familiar with the total political literature of the period and with the various personalities to be competent to weigh that which I have read.

Speaking of Washington in the bicentennial year of his birth Professor Schlesinger said:

"His decision not to accept a third term has become embodied in our unwritten constitution, yet most Americans would be surprised to learn the reason for Washington's abstention. It was not that he thought a third term of office would be undemocratic, but that he was old and tired and anxious to return to the bucolic peace of his Virginia plantation. "While choice and prudence invite me to quit the political scene" he declared in his Farewell Address," patriotism does not forbid it."[6]

So President Wriston and Professor Schlesinger disagree in their interpretations as so many doctors do in so many matters. When doctors disagree it may be that neither can be either right or wrong simply because the facts are too scanty or in too much apparent contradiction or simply too indefinite to make possible a decision either right or wrong;

[5] *Writings of James Madison, vol. 1, p. 566, Lippincot 1865.*

[6] *A. M. Schlesinger, Harvard Graduates' Magazine, March 1932, p. 223.*

one may remain and have long to continue in a state of suspended judgment if one is determined to be scientific.

You are of course by this time impatient with my short and frivolous reference to statistics and with my long and labored discussion of a controversy relative to historical interpretation. You may feel that all this has nothing to do with the place of statistics in child development, and I cannot be sure that it has, except that I should hope that neither the statistics nor the histories of the children would be less accurate or less definite than those we have found in print and on the air these past weeks. And yet I don't know. You see I am no more expert in child development than I am in history. There is little known to me, yet that little is too much for my competency to weigh. If my parable has been so elongated that you consider it quite parabolic, I might get us back to business by raising the question of the present true scientific status of this nature-nurture controversy of yours - this Stanford-Iowa campaign with Terman vs. Stoddard. I have heard competent authority say that we had a Yearbook on the subject a dozen years ago which got us fairly well settled in what we knew and that we have a new Yearbook now which upsets it all. I have heard competent authority say that there have been meetings for the discussion of these matters at which the discussion was mere oratory, appeal to authority, underinterpretation, overinterpretation and misinterpretation of mostly inadequate facts from small or conflicting or indefinite samples, and general misapplication of failure in application of wellknown and appropriate statistical methods. I don't know. I leave it to you, for surely it is a central theme in child development, though it may not be much in evidence on your program for this meeting.

The growth of our knowledge about intelligence tests has been slow, the tests have had to be evolved, they have had to be applied to many and various groups of persons, statistical methods of treating the results have had to be developed, and as all this has gone forward we have reached a stage where special studies of particular problems with special observational set-ups have become possible with some hope of solution. Ars longa, vita brevis. Yet with it all the question of nature-nurture remains unsettled. The situation with respect to personality tests and vocational guidance is less advanced and to many persons seems quite unsatisfactory. In my opinion, which is only an incompetent opinion, we are far from ready even to dispute over the contributions of nature and nurture in the domains of personality and of vocational fitness. It is always helpful to scientific advance if there be found definite physically measurable quantities which bear effectively on our problems, perhaps the work going on in the field of endocrine studies will furnish one basis for a better understanding of some of these developmental problems.

Let me quote once more from Professor Schlesinger's paper on Washington:

> "It should be said, however, that the secret of his greatness as President is to be found less in his ability to originate policies than in his willingness to seek counsel, in his high-mindedness and in the sobriety of his judgment. He was endowed with a goodly share of that stupidity which someone has called God's gift to the English people, a quality of mind which made him deliberate in action,

somewhat inarticulate of speech and always a man of affairs rather than a closet theorist."[7]

Whether you agree with the characterization or not, you do feel, I am sure, that some characteristics other than those now measured as intelligence are of vital importance in men and women. Indeed Chester Barnard in discussing qualities of leadership[8] puts several above intelligence; e.g., vitality, decisiveness and persuasiveness. Have we for any of these or for health an index as good as our intelligence indices with which we could study the role of heredity and environment upon health or the correlation of health with other characteristics? We shall not get far by taking the first health index we happen to construct, applying it to large groups of persons and then trusting to statistical methods to give us sound results independent of the inadequacies of the index. The notion that with enough bad data, good results may be had by the application of enough statistical procedures has been pretty thoroughly exploded by the disappointing and fallacious findings of those who have trusted to this way of life in science.

You have of course some special difficulties in the study of child development which inhere in the fact that development is a serial process, you have to deal with time-series. So does the economist. Unfortunately the theory of time-series is not in a satisfactory state of development even in economics despite the large amount of work which has been done upon it. And it is far from certain that had we a first class method of dealing with economic time-series, we could simply transfer that method to biological time-series. Much has been made by R. A. Fisher of his experimental techniques of randomization; it is hard to randomize a group of children as you would plot out a group of fields for examining the yields of wheat under different treatments of the soil or with different strains of seed. In respect to your time-series the growth process itself seems hostile to the very idea of randomization. From a practical statistical point of view such an elementary concept as the rate of growth during a period has its difficulties because you have to compare two weights or heights or other measurements which are fairly near together and even if there were no errors of measurement the natural fluctuations in weight or the variations of the measures of height due to uncontrollable variations of posture, render the differences of successive measurements tolerably unstable material with which to work.

There are many many statistical methods which have been developed. Some of these are of only mathematical interest. It may be that at some future time they may find useful application. Most of them, however, have already been successfully applied to some sort of data in some fields of science. To collect all these methods would mean to compile a very large volume, or even a series of volumes. It is quite impracticable to teach all these methods to any group of persons, and it would be quite useless to do so because no group of workers in any field, not even one so broad and varied as child development, is likely to need more than a small fraction of them. On the other hand it is more than likely, it is almost certain that for some problems which have already arisen new statistical methods must be developed before complete use of the data can

[7] *A. M. Schlesinger, Harvard Graduates' Magazine, March 1932, p. 222.*
[8] *Harvard Business Review, Spring 1940.*

be made. You have therefore need of well-trained and resourceful statisticians in some aspects of your work. More than these, you must have intuitive scientific personnel widely informed by constant personal experience with children to imagine and to formulate the important problems for investigation and to sense those variables which must be measured if the problems are to be solved.

Very often some group collects interminable masses of data because that data can be collected and then comes to the statistician expecting that he has the magic touch that can turn all this to scientific gold, expecting even that though he knows nothing about the field of inquiry he can by application of routine methods find the significance of the material. Generally speaking that simply cannot be done. Of course if all that is wanted is that data be tabulated and graphed, that means and standard deviations be calculated, or that other formal procedures be applied, that can be done routinely, but that will not elicit the important problems and until they have been elicited they cannot be solved. As one of our Tercentenary guests from a relatively small and poor country, who had used his invitation to enable him to travel somewhat widely in ours, remarked to me: It is marvelous, this country, you have so many institutions, so much money, so large a research staff in so many places and such collections of data, but I have such difficulty in finding what are the problems on which you work, what are the ideas with which you are working; you just work, work prodigiously; alas, my country is so poor we must have a problem and an idea before we start! It is only fair to say that in my opinion in his country they are so poor that they often have nothing but problems and ideas, no data, and thus remain too exclusively in the field of a priori dialectic instead of emerging into scientific accomplishment. Both extremes must be avoided.

You will have seen that in my opinion the place of statistics in studies of child development, as indeed in many other studies, is a rather modest one, a useful working tool in the hands of persons of competent scientific mind. This is likely to be the case in any nascent field, in any field during its period of early growth - its childhood if you will. Here it is simple tentative exploratory processes that are most fertile. When a field has become well developed with its larger etiology already determined, and great collections of data of known competency to lead to specific results have been made, then statistics may be about all one does need. The job may be very necessary like the calculation of those tables by which the navigator of a ship locates his position at sea, but it is no longer very stimulating as science. You have the satisfaction of working in a nascent field which by its nature is of the highest importance and by its state of development most exciting.

STUDY OF THE NUTRITION OF GROUPS OF CHILDREN SELECTED ON THE BASIS OF NO DEFECTIVE DECIDUOUS TEETH AND HIGH INCIDENCE OF DEFECTIVE DECIDUOUS TEETH[1]

BERTHA SHAPLEY BURKE[2]

The Department of Child Hygiene of the Harvard School of Public Health established ten years ago the Center for Research in Child Health and Development. The Center was planned primarily to provide facilities for research upon well children living at home under normal conditions. These children, approximately three hundred in number, were enrolled at the Center, and of these, two hundred and twenty-five are still being studied from early in prenatal life through a major portion of their developmental period.[3] The oldest children in the group are now ten years of age.

A statistical analysis of the incidence of defective deciduous teeth among children enrolled in the study has been made by Miss Margaret F. Allen, Department of Vital Statistics, Harvard School of Public Health.[4] Following this statistical analysis, a preliminary study of the nutrition of small groups of our children, selected by Miss Allen on the basis of no defective deciduous teeth and high incidence of defective deciduous teeth, was undertaken. The dental data upon which the statistical analysis and this preliminary study are based have been collected under the direction of Dr. Frederick C. Allen of the Forsyth Dental Infirmary.[5]

The groups selected represent Group I, those children who have reached six and one-half years of age with no defective teeth; Group II, those children with the highest incidence of defective deciduous teeth at three years of age; and Group III, those children who had perfect teeth at three years of age but developed the highest incidence of defective teeth by four years of age.

This preliminary study of these three groups was undertaken to discover what, if any, significant differences could be found in these groups of children which might explain why some children were able to go through as much as six and one-half years of life with no defective deciduous teeth, while others of our children showed a high incidence of defective teeth by three years of age. The more significant differences seem on this small number of cases to appear in the field of nutrition or in factors related to nutrition.

In this preliminary study each case has been considered individually in considerable detail. All of the material presented in the charts which follow has been independently collected and analyzed by those of

[1]*From the Department of Child Hygiene, Harvard School of Public Health and the Forsyth Dental Infirmary, Boston, Massachusetts, carried out under a grant from the General Education Board. Preliminary report presented at the Fourth Biennial Meeting of the Society for Research in Child Development held at the Harvard Medical School, Nov. 9, 1940.*

[2]*From the Center for Research in Child Health and Development, Harvard School of Public Health, Boston.*

[3]*Stuart, H. C. and Staff: "The Center, the Group Under Observation, Sources of Information, and Studies in Progress." Monograph of the Society for Research in Child Development, National Research Council, Washington, D. C. Vol. 4, No. 1, 1939.*

[4]*To be published.*

[5]*Dr. F. C. Allen has been assisted in the collection of these data by Dr. J. Murray Gavel and Dr. Philip Williams.*

us working in our separate fields. The findings have been grouped and are being presented as factual data only. No conclusions are being drawn.

This preliminary study was undertaken on the extremes of the entire group to obtain, if possible, leads for studying our entire group of children in regard to the causes of defective deciduous teeth. This preliminary report will be followed by a more complete investigation of all of our cases including not only the extremes, as shown in these small groups, but all intermediate cases.

The observations on these cases, representing as they do the most extreme deciduous tooth conditions in our entire group of children, are shown in the following charts and justify further study.

A STUDY OF THE NUTRITION OF GROUPS OF CHILDREN SELECTED ON THE BASIS OF NO DEFECTIVE DECIDUOUS TEETH AND HIGH INCIDENCE OF DEFECTIVE DECIDUOUS TEETH

GROUPS	I	II	III
Classifications	No defective deciduous teeth through six and one-half (6½) years of age.	Largest incidence of defective deciduous teeth at three (3) years of age	No defective deciduous teeth at three (3) years of age. Incidence of defective deciduous teeth greatest for entire group between three (3) and four (4) years of age
Incidence of defective deciduous teeth within groups	0	Worst mouth 9 teeth Best mouth 3 " Average 4.5 "	Worst mouth 9 teeth Best mouth 3 " Average 5.2 "
Number cases in each group	11 (One set twins)	12 (One a twin)	12 (One a twin)
Distribution of cases according to sex	Females 4 Males 7	Females 9 Males 3	Females 7 Males 5
Place of child in family group	1st born 9 (including twins) 2nd born 2	1st born 6 2nd " 4 4th " 1 5th " 1 (smallest of twins)	1st born 6 2nd " 4 3rd " 1 4th " 1

A STUDY OF THE NUTRITION OF GROUPS OF CHILDREN SELECTED ON THE BASIS OF NO DEFECTIVE DECIDUOUS TEETH AND HIGH INCIDENCE OF DEFECTIVE DECIDUOUS TEETH

GROUPS	I		II		III	
Number of Defective teeth In parent (Mother)	Worst mouth Best mouth Average (1 case not included, no examination)	25 10 18.2	Worst mouth Best Mouth Average	32 15 22.9	Worst mouth Best Mouth Average (1 case not included, no examination)	31 11 20.8

General Average All Groups Together = 20.6

GROUPS	I		II*		III	
Subjective health ratings of children Excellent = 5 Very good = 4 Good = 3 Fair to poor = 2 Poor = 1	Infancy (Birth to 2 yrs.) Early childhood From 2 - 3 yrs. From 3 - 4 yrs. From 2 - 6½ yrs.	3.1 3.2 3.0 2.8	Infancy (Birth to 2 yrs.) Early childhood From 2 - 3 yrs. From 3 - 4 yrs. From 2 - last exam.	2.9 2.9 2.6 2.8	Infancy (Birth to 2 yrs.) Early childhood From 2 - 3 yrs. From 3 - 4 yrs. From 2 - 4 yrs. From 2 - last exam.	2.9 2.6 2.6 2.6 2.3

*Three poorest children at birth examination in this group:

1. Child with cleft palate (Mother pernicious vomiter during pregnancy).
2. Child - premature 3 lbs. 4 oz. (Mother nauseated 7 mos. of pregnancy).
3. Child "structurally immature" (Mother anorexia last 3 mos. of pregnancy; lost 10 - 12 lbs. in this period).

Prepared for the author by Dr. Edward L. Tuohy from the pediatric records.

SIGNIFICANT DIFFERENCES IN THE PRENATAL PERIOD

GROUPS	I	II	III
Amount of nausea experienced by mothers during pregnancy	None 8 Considerable 1 Slight (Mother of twins) 1	None 3 Active nausea 8 Pernicious vomiter 1 Ill with nausea 7 mos. 1 No data 1	None 3 Active Nausea 8 Slight 1
Amount of illness other than nausea experienced by mothers during pregnancy	Totally uneventful 6 Slight illness 3 Placenta Previa 1	Totally uneventful 1 Course normal except nausea 2 Definite illness 6 (+2 severely ill from nausea) Underweight 25 lbs. at onset 1	Totally uneventful 2 Slight illness 6 Definite illness 4 (One also markedly under-weight at onset)
Amount of milk in diet daily during pregnancy	1 quart (at least) 8 3/4 quart to middle 3rd trimester: then 1 quart 1 1 pint 1st trimester; then 3/4 to 1 quart 1 Most of women in this group like milk and include it in their daily diet.	2 - 3 quarts (?) 1 (Data known to be totally unreliable in several fields.) 1 quart (?) 1 Approx. 16 - 18 oz. 2 Under 1 pint major part of pregnancy - 2 improved to 3/4 quart last trimester 8 Many mothers in this group dislike milk.	Milk intake in this group more variable (?) 1 - 1½ quarts 1 (?) 3/4 to 1 quart 1 1 pint - 1 quart 1 1 pint 6 mos. then 3-4 cups 1 1 pint throughout 1 Under 1 pint for 4 months; then improved (20-24 oz. - occasionally more) 7 Many mothers in this group dislike milk.
Cod liver oil or equivalent taken daily by mother	None 8 C.L.O. 1 tbsp. last 6 wks. 1 Viosterol 9 gtts. last 2½ months 1	None 9 C.L.O. 1 tbsp. last 4 mos. 1 Haliver oil + viosterol last 4 mos. (1 cap.) 1 Viosterol or haliver oil capsule last 2 months 1	None 7 Haliver oil + viosterol 1 - 2 cap. per day last 2 - 5 mos. 3 Haliver oil or viosterol 1 cap. per day 5 months 1 (?) A, B, D cap. per day last 6 months 1

A STUDY OF THE NUTRITION OF GROUPS OF CHILDREN SELECTED ON THE BASIS OF NO DEFECTIVE DECIDUOUS TEETH AND HIGH INCIDENCE OF DEFECTIVE DECIDUOUS TEETH

SIGNIFICANT DIFFERENCES DURING INFANCY (BIRTH TO 2 YEARS)

- 1 -

GROUPS	I	II	III
Amount Breast Feeding	Entirely B. F. to 6 mos. or more 4 Largely B. F. to 6 mos. 2 Very little B. F. 4 None 1	Largely B. F. to 6 mos. 1 (Mother's diet poor in milk) Entirely B. F. to 3 mos. 3 (B. M. inadequate in amount and mother's diet poor in milk) B. F. 1 - 2 mos. 5 (Unsatisfactory all cases) In premature nursery 1 (B.L.I.) 49 days - little B.F. Cleft Palate 1 (Fed with Breck Feeder) B. F. 16 days 1 (Unsatisfactory)	Entirely B. F. to 6 mos. or more (Mother's diet poor in milk) 1 Largely B. F. to 6 mos. 1 (Mother's diet fair in milk) Entirely B. F. to 3 mos. 2 (Mother's diet fair to good in milk) B. F. Approximately 1 mo. 5 (Unsatisfactory all cases) Practically no B. F. 3 (Unsatisfactory)
Milk intake other than breast	Good or excellent to 2 years 8 Good or excellent to 1 year (Poor at 18 mos.) 2 Difficulty for 2 short periods only 1	Good from 3 mos. (B. F.) 1 Fair from 6 mos. (B. F.) 1 Fair to 3 mos. and again 1 - 2 years 1 Poor to 3 mos. 2 Poor to 6 mos. 6 (2 continued poor to 9 mos.) Poor practically throughout 1	Good to excellent to 1 yr. Poor 1 - 1½ yrs. 1 Good to excellent after 6 mos. 1 Fair to good after 6 mos. 1 Poor 1 month 1 Poor to fair to 3 mos. and again around 18 mos. 2 Poor to fair to 6 mos. 3 Poor to fair practically throughout 3

A STUDY OF THE NUTRITION OF GROUPS OF CHILDREN SELECTED ON THE BASIS OF NO DEFECTIVE DECIDUOUS TEETH AND HIGH INCIDENCE OF DEFECTIVE DECIDUOUS TEETH

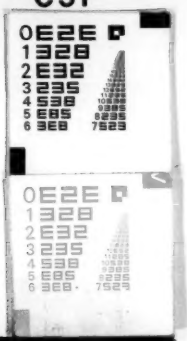
SIGNIFICANT DIFFERENCES DURING INFANCY (BIRTH TO 2 YEARS)

- 2 -

GROUPS	I	II	III
Considering adequacy of B. F. + milk other than breast	Excellent 2 Good or excellent 6 Good or excellent to 1 year; poor at 18 mos. 2 Slight difficulty 2 short periods 1	Good from 3 mos. 1 Fair from 6 mos. 1 Fair to 3 mos. and again 1 - 2 yrs. 1 Poor to 3 mos. 2 Poor to 6 mos. 4 Poor to 9 mos. 2 Poor practically throughout 1	Good to excellent 1 year; poor 1 - 1½ years 1 Good to excellent after 6 mos. 1 Fair to good after 6 mos. 1 Poor 1 month 1 Poor to fair to 3 mos. 2 Poor to fair to 6 mos. 3 Poor to fair practically throughout 3
Appetite	Usually good or excellent	Varied Good many poors	Varied Good many poors
Amount of cod liver oil or equivalent	Good or excellent 7 No data first year; then good or excellent 1 Poor to 5 months; then excellent 1 Practically none 2	Excellent largely from 6 mos. 7 Poor to 3 months 6 Poor to 6 months 4 Poor all first year 2 Others variable at different periods	Excellent throughout 1 Poor to 3 months 7 Poor to 9 months 3 (Rest of periods on above 10 usually good or excellent) None 1

A STUDY OF THE NUTRITION OF GROUPS OF CHILDREN SELECTED ON THE BASIS OF NO DEFECTIVE DECIDUOUS TEETH AND HIGH INCIDENCE OF DEFECTIVE DECIDUOUS TEETH

SIGNIFICANT DIFFERENCES IN EARLY CHILDHOOD (FROM 2 YEARS)

Groups	I (2-6½ yrs.)	II (2-3 yrs.)	III (2-4 yrs.)
Milk intake 1 quart = excellent 24 ozs. = good 20 ozs. = fair 16 ozs. = poor or less	Good or excellent 6 Fair or poor at 2 intervals 3 Fair or poor at 3 intervals 1 Intake varied widely many intervals 1	Good or excellent 5 Good or fair largely 4 Poor to fair 1 Poor 2	Good or excellent 4 Fair or poor at 1 interval 4 Fair or poor at 2 intervals 1 Poor or fair 2 Poor 1
Cod liver oil	Excellent usually 7 Irregularly but considerable 3 None 1	Excellent usually 8 Irregularly but considerable 2 Definitely poor 2	Excellent usually 10 Some ? Amount 1 Practically none 1
Appetite	Very varied ratings	Very varied ratings	Very varied ratings many more poors 3 - 4 years than in groups I and II
Amount of sweets or excessive starches	Very little candy or ice cream or other sweets 6 Ice cream daily in summer at several intervals 5 (6 of the 11 with one or more periods high in cereal or other carbohydrate food)	Very little candy or ice cream or other sweets 7 Excessive sweets 5 (Excessive cereal and bread in 1 of these)	Very little candy or ice cream 4 Excessive candy, ice cream or other sweets especially 2½ - 4 yrs. all or some periods 8 (Excessive bread and cereal in 2 of these)

C51